EXHIBIT 5
(PART 2 OF 2)

D14509-0413

Figure 33. Electrical lead from the door switch welded/affixed to the drum edge.

D14509-0158

Figure 34. Garments identified as laundry load, including jeans, underwear and t-shirts.

2.5.3 Cabinet Interior

Examination of the cabinet interior showed a thick coating of lint on the cabinet floor and walls (Figure 35). The coating of lint on the bottom left of the cabinet measured around 10 mm thick. There was also some debris likely associated with the drum load in the base of the cabinet. Plastic components including the air duct and blower assembly were partially consumed and melted to the base of the cabinet (Figure 36 and Figure 37). There was some unburned lint protected beneath the molten plastic and adhered to it. This heavy accumulation of lint is consistent with the interior exhaust tube being separated from the blower housing.

The motor was found in the base, with lint adhered to it (Figure 38). Some of the windings had apparently melted. The shaft was seized and the centrifugal switch was immobile. Due to the magnitude of damage during the fire, I could not rule out an electrical or mechanical fault in the motor.

D14509-0363 cropped

Figure 35. Dryer cabinet after removal of drum during my inspection.

D14509-0536

Figure 36. Base of the cabinet.

D14509-0542

Figure 37. Base of cabinet beneath melted plastic components.

D14509-0362

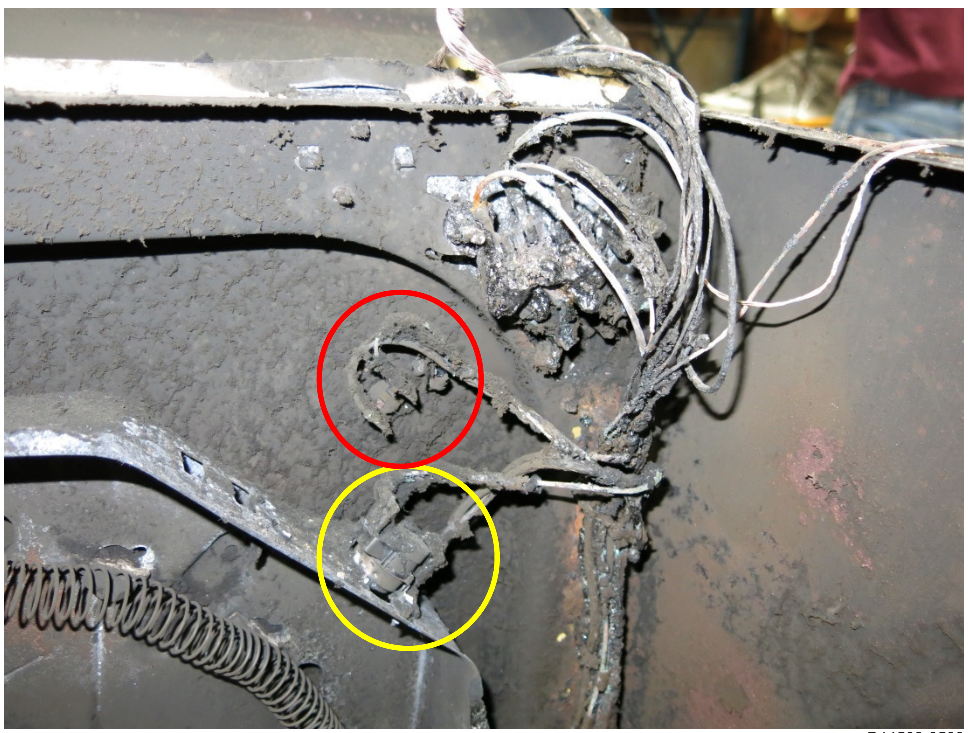
Figure 38. Motor with melted windings.

The control thermostat was in the base of the cabinet, damaged by fire but mostly intact (Figure 39). The control thermostat was not functionally tested because of the fire damage. The high-limit thermostat was found in place at the one o'clock position on the heater pan, with some lint adhered to it and around it (Figure 40). The high-limit thermostat successfully operated when functionally tested. The contacts exhibited signs of previous activity, but were not welded (Figure 41). The thermal limiter (also in Figure 40) was found in place but had no continuity when tested, suggesting that it had opened at some point during the fire.

Electrical leads to the door switch were beaded and severed at the bulkhead entry inside the cabinet, and a conductor to the drum light was also melted. The severed line was broken at the front panel side. The door switch lead was welded to the drum edge. A smaller diameter cord at the front panel side of the cabinet was also melted. The observed electrical activity could be caused by fire attack, whether or not the dryer was running. Electrical activity, such as that caused by surface arc tracking or another component failure, is capable of igniting accumulated lint; however, giving the timing of the fire discovery and limited extent of damage, I was able to refute electrical fault while the dryer was running as a cause of the fire.

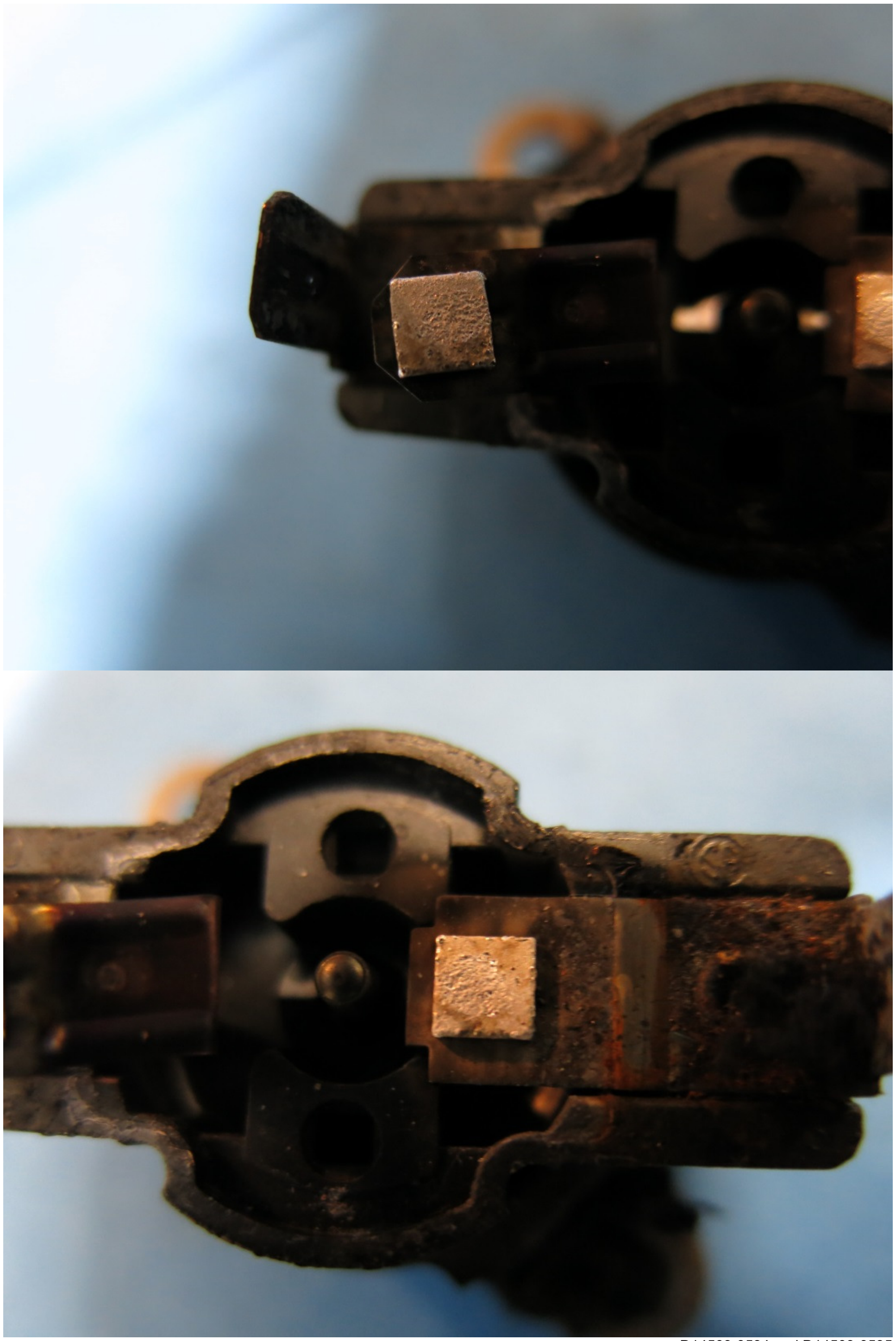
D14509-0399 cropped

Figure 39. Control thermostat found in the base of the dryer cabinet.



D14509-0500

Figure 40. High-limit thermostat (circled in yellow) and thermal limiter (circled in red).



D14509-0534 and D14509-0535

Figure 41. Contacts of high limit thermostat showing some pitting.

D14509-0309

Figure 42. Beaded wires at rear bulkhead entry.

2.5.4 Electric Heater System

The heater pan showed signs of oxidation and soot deposition during the fire (Figure 43). There was some lint or debris on the back wall of the heater pan, although I could not determine if this lint was there prior to suppression efforts. There were thick lint deposits around the rear bearing support bracket, visible through the central hole in the heater pan. There was a thin coat of partially heat-affected lint at the base of the heater pan, but it did not appear to have been directly involved in the fire (Figure 44).

Some larger agglomerations of lint were found in the base of the heater pan, but likely fell there during suppression efforts or later movement of the appliance. I would expect lint in these locations to have been consumed, had it been located there during operation of the heating element. The Wright Group claimed that this lint "was evidence that the fire was caused when lint that detached from the rear or the drum or from areas where lint had collected in the heater pan above had detached and fallen onto the heating element". However, they did not explain why this lint was not consumed by the fire, had it been located in this area while the heating element was energized. This ignition mechanism is also inconsistent with the discovery of the fire over 5 hours after the dryer was started, and approximately 4 hours after the heating element would have been de-energized.

The heating element was tested for electrical continuity, and was found undamaged and having a resistance of 11.6 ohms. The heating element had not grounded to the heater pan, and there was no indication that electrical activity associated with the electric heater system was the cause of the fire.

D14509-0369

Figure 43. Heater pan and heater coil.

D14509-0376

Figure 44. Thin coat of lint in the base of the heater pan. The larger agglomerations of lint on and beneath the heating coil were not likely there prior to or during the fire.

3 Conclusions

The presence of vegetable-derived oils was detected in a sample of the drum load. Vegetable-derived oils can self-heat leading to spontaneous combustion of a load in the drum or outside the dryer. Spontaneous combustion of a tumbling drum load with forced airflow through the load is unlikely to occur; however, it is feasible that a tumbling load with a blocked exhaust may lead to spontaneous combustion given a high enough reactivity of the material. If the load was stopped hot, it is also more likely for a vegetable-derived oil-contaminated load to self-heat. This load contained garments belonging to the Stephans' 13-year old son. The dryer was started shortly before 7 am on a school day, and it is feasible that their son stopped the dryer to retrieve a garment but did not restart it. This hypothesis was not pursued during the early investigation, witness interviews, or deposition testimony to my knowledge; hence, it cannot be refuted given the available information.

The exhaust system of the McCants clothes dryer did not comply with the installation instructions. The screen on the vent hood was mostly restricted by lint, and the vinyl transition duct also promoted the accumulation of lint. The evidence indicates that the interior exhaust tube was separated from the blower at some point prior to the fire, which likely contributed to the excessive accumulation of lint in the dryer cabinet. However, given the timing of the fire, it is unlikely that this lint was ignited by the dryer while operating.

Based on the witness testimony, the inside of the dryer cabinet was not cleaned during the approximately 5 1/2 years of service for the dryer. The dryer and exhaust installation coupled with a failure to have the interior of the dryer cabinet cleaned allowed hazardous quantities of lint to accumulate in the mechanical compartment in the base of the appliance.

The Plaintiff's universal lint defect hypothesis was not supported by evidence, which indicates that the fire originated outside of the exhaust air stream. The Wright Group's conclusion as to the cause of the fire is incorrect because it is not uniquely consistent with the evidence or fire dynamics. Mr. Stephan discovered the fire approximately 5 hours after the dryer was started, and approximately 4 hours after the dryer would have ceased operation.

The most likely cause of this fire was spontaneous combustion of the drum load.

Appendix A

Curriculum Vitae of Delmar "Trey" Morrison, Ph.D., P.E., CFEI

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Delmar "Trey" Morrison, III, Ph.D., P.E., CFEI
Principal Engineer

Professional Profile

Dr. Delmar "Trey" Morrison, III is a Principal Engineer in Exponent's Thermal Sciences practice. Dr. Morrison's practice areas encompass product safety, product liability, and chemical process safety. He specializes in investigations of origin, cause, and engineering issues related to hazardous chemicals incidents, fires, explosions, and chemical technology. Dr. Morrison's expertise includes chemical engineering, fire dynamics, and the system safety of products and processes. Dr. Morrison's doctoral studies in Chemical Engineering focused on the safety of self-heating materials and reactive chemical hazards. He developed highly specialized skills in the application of ignition theory of solid materials to wood and other cellulosics through external heating and spontaneous ignition as a result of internal self-heating. He applies these skills to accident scenarios ranging from spontaneous ignition of oil-contaminated fabrics to self-heating of bulk solid oxidizers.

Dr. Morrison provides consulting services for a variety of industries. Beyond the wide range of consumer and industrial systems he evaluates, he has focused on heating systems including residential and commercial clothes dryers and industrial process dryers, ovens, and furnaces. He has also focused on oil-flooded screw air compressors and other positive displacement gas compressors. He provides analyses of heat-producing processes such as self-heating materials, ignition, and combustion. As a chemical engineer, his areas of expertise include chemical process safety management and analyzing the effects of chemical plant operator actions, control system response, and process unit response during upset situations and hazardous operations that may lead to a hazardous release. As part of Dr. Morrison's proactive safety consulting services, he leads hazard and risk assessments using industry-accepted process hazard analysis (PHA) methods such as HAZOP studies, What-If studies, and LOPA studies, combined with analytical techniques such as Fault Tree Analysis, Event Tree Analysis, Root Cause Analysis, and Consequence Analysis.

Dr. Morrison is an active professional in the product safety and chemical process safety communities. In addition to his technical committee memberships and publications, he has served in leadership roles in the field of chemical process safety through process safety conferences sponsored by the American Institute of Chemical Engineers. Most recently, Dr. Morrison was the Global Congress Chair for the 8th Global Congress on Process Safety in 2012, which had approximately 1000 domestic and international attendees from the fields of process safety and risk analysis. The objectives of these activities are to aid in the prevention of major loss incidents that involve fires, explosions, runaway reactions, and hazardous material releases in the chemical, petrochemical, and related industries.

Academic Credentials and Professional Honors

Ph.D., Chemical Engineering, Illinois Institute of Technology, 2008
M.S., Chemical Engineering, Oklahoma State University, 1998
B.A., Chemistry (College Honors in Inorganic Chemistry), Knox College, 1996

Licenses and Certifications

Registered Professional Engineer, Illinois, #062-059506; North Carolina, #037722; South Carolina, #28918
Certified Fire and Explosion Investigator, Reg. No. 12900-6508
40-Hour OSHA Certification, Hazardous Waste Operations and Emergency Response
40-Hour Training, Process Hazard Analysis (PHA) for Team Leaders

Professional Affiliations

Process Safety

- Session Chair for Case Studies and Lessons Learned, 2014 Global Congress on Process Safety
- American Institute of Chemical Engineers (Senior Member)
- Safety & Health Division of AIChE (Member)
- Member of the American Institute of Chemical Engineers (AIChE) Loss Prevention and Process Safety Programming Committee (Area 11a of the AIChE Safety & Health Division)

Fire Safety

- National Fire Protection Association (member)
- National Association of Fire Investigators (member)
- Alternate Member: Technical Committee on Ovens and Furnaces, NFPA 86 *Standard for Ovens and Furnaces*, National Fire Protection Association

Product Safety

- Member of Underwriters Laboratories Standards Technical Panel (STP) for UL 2157, Standard for Electric Clothes Washing Machines and Extractors
- Member of Underwriters Laboratories Standards Technical Panel (STP) for UL 2158, Standard for Electric Clothes Dryers, and
    - Task Group to Address Requirements for Clothes Dryer Status Indicators

Past Professional Affiliations/Positions

Process Safety

- Chair of the AIChE Loss Prevention and Process Safety Programming Committee for 2012–2013
- Session Co-Chair for Consequence Analysis I & II, 2013 5th CCPS Latin American Conference on Process Safety, Cartagena, Columbia

- Session Chair for the Analysis of High Consequence Offsite Events, 2013 Loss Prevention Symposium
- Session Chair for Lessons Learned from Mentoring in the Process Safety Organization, 2013 Process Safety Management Mentoring Symposium
- Session Chair for Fires & Explosions – Fundamental Understandings for Professionals New to the Field, 2013 Process Safety Management Mentoring Symposium
- Global Congress Chair for the 2012 8th AIChE Global Congress on Process Safety, Houston, Texas
- Session Chair for Indicators and Metrics in Process Safety, 2012 4th CCPS Latin American Conference on Process Safety, Rio de Janeiro, Brazil
- Symposium Chair for the 2011 45th AIChE Loss Prevention Symposium, Chicago, Illinois
- Global Congress Vice Chair for the 2011 7th AIChE Global Congress on Process Safety, Chicago, Illinois
- Chair for Management of Change Session, 2011 3rd Latin CCPS Conference, Buenos Aires
- Symposium Vice Chair for the 2010 44th AIChE Loss Prevention Symposium, San Antonio, Texas

Product Safety

- Member of Underwriters Laboratories Task Group for Clothes Dryer Exhaust Duct Power Ventilators

Journal Articles and Technical Publications

Ibarreta AF, Ponchaut NF, Hart RJ, Morrison DR, Kytömaa HK. Using passive methods to reduce flammable release hazards at LNG facilities. FS-World Magazine "Oil & Gas Industry" edition, accepted for March 2014.

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Morrison DR, Fecke, M. Evaluating self-heating and ignition hazards in combustible dust handling equipment. 5th CCPS Latin American Process Safety Conference and Expo, Cartagena, Columbia, August 12–14, 2013.

Morrison DR, Marr KC. Guidelines for applying process hazard analysis techniques to combustible dust applications. 5th CCPS Latin American Process Safety Conference and Expo, Cartagena, Columbia, August 12–14, 2013.

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Barrera CA, Morrison DR, Ogle RA. Using LOPA to establish SILs for power outage protection. Presentation at the American Institute of Chemical Engineers, 2012 Spring National Meeting, 14th Annual Process Plant Safety Symposium, Houston, TX, April 1–5, 2012.

Ogle RA, Morrison DR, Hart RJ. Thermodynamic models for leak detection of natural gas in salt cavern storage. American Institute of Chemical Engineers, 2011 Annual Meeting, Minneapolis, MN, October 19, 2011.

Morrison DR, Hart RJ, Heckel P. Exposing the blurry lines between personal safety and process safety education: contrasting NIOSH prevention through design (PtD) with CCPS Sache. American Institute of Chemical Engineers, 2011 Annual Meeting, Minneapolis, MN, October 18, 2011.

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Morrison DR, Fecke M, Martens J. Migrating an organizational incident reporting system to a CCPS process safety metrics model. 2010 Annual Symposium, Mary Kay O'Connor Process Safety Center, Texas A&M University, College Station, TX, October 2010.

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Morrison DR. Analysis of a two decade old arson investigation using scientific fire investigation methods: The People vs. Madison Hobley. Invited guest lecture, Knox College Forensic Sciences Class, October 2009.

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Morrison DR. Industrial accident investigation. Lecture in the McCormick School of Engineering and Applied Science, Northwestern University, May 20, 2009.

Morrison DR, Martens JD, Ogle RA, Cowells JT. Root cause analysis of a cryogenic refrigeration system explosion. American Institute of Chemical Engineers, 2009 Spring National Meeting, 43rd Annual Loss Prevention Symposium, Tampa, FL, April 26–30, 2009.

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Morrison DR. Thermal ignition studies of wood flour. Ph.D. dissertation in Chemical Engineering, Illinois Institute of Technology, May 2008.

Morrison DR. Self-heating materials and thermal stability hazards. Lecture in the School of Engineering, Stanford University, May 5, 2008.

Morrison DR, Ogle RA. Evaluating kinetic parameters for solid substances exhibiting complex self-heating behavior. American Institute of Chemical Engineers, 2008 Spring National Meeting, 42nd Annual Loss Prevention Symposium, New Orleans, LA, April 7–9, 2008.

Dillon SE, Carpenter AR, Ogle RA. Comparative fire risk of motor vehicle fuels: Gasoline vs. ethanol. Presented at American Institute of Chemical Engineers, 2008 Spring National Meeting, 42nd Annual Loss Prevention Symposium, New Orleans, LA, April 7–9, 2008.

Morrison DR, Ogle RA, Gidaspow D. A new assessment of the finite Biot number correction to thermal ignition tests. American Institute of Chemical Engineers, 2007 Annual Meeting, Salt Lake City, UT, November 8, 2007.

Morrison DR. Transient self-heating vs. steady state theory for ignition of wood flour' and 'scientific investigation of incendiary fires.' Invited guest lectures, Knox College Chemistry Department, October 2006.

Morrison DR, Su YS, Fecke MJ. Spontaneous combustion tendency of household chemicals and clothes dryers. 2006 International Appliance Technical Conference, March 2006. This paper received the Dana Chase Memorial Award for the Best Paper presented at the conference.

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Caligiuri RD, Morrison DR. Using root cause analysis in product safety investigations. Presentation for Association of Home Appliance Manufacturers Product Liability Seminar, Washington, D.C., October 2005.

Morrison DR, Ogle RA, Viz MJ, Carpenter AR, Su YS. Investigating chemical process accidents: examples of good practices. Engineers Process Plant Safety Symposium, 2005 Spring National Meeting, American Institute of Chemical Engineers, Atlanta, GA, April 11–13, 2005.

Ogle RA, Morrison DR, Carpenter AR, Su YS. Missed opportunities in reactive chemical hazard evaluations. 39th Annual Loss Prevention Symposium, American Institute of Chemical Engineers Spring National Meeting, April 11–13, 2005.

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Ogle RA, Carpenter AR, Morrison DR. Lessons learned from fires and explosions involving air pollution control systems. 38th Annual Loss Prevention Symposium, American Institute of Chemical Engineers, New Orleans, LA, April 2004.

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Ogle RA, Carpenter AR, Morrison DR. Explosion of a railcar containing toluene diisocyanate waste. 18th International CCPS Conference and Workshop: Managing Chemical Reactivity

Hazards and High Energy Release Events, American Institute of Chemical Engineers, September 25, 2003.

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Appendix B

Testimony List for Delmar "Trey" Morrison, Ph.D., P.E., CFEI

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Deposition / Trial Testimony

Depositions

Employers Mutual Cacualty Companies as subrogee of Total Source Manufacturing, Inc., et. al., vs. Sullair Corporation and TMI Compressed Air Systems, Inc., State of Michigan in the Circuit Court for the County of Jackson, Case No. 10-03448 NP, Warrenville, Illinois, May 3, 2013.

Homesite Insurance Company of the Midwest as subrogee of Bill and Jennifer Heimann, vs. Electrolux Home Products, Inc. and Sears Roebuck and Company, United States District Court for the Northern District of Indiana, Fort Wayne Division, Case No. 1:11-cv-00042-WCL-RBC, Chicago, IL, March 7, 2013.

Liberty Mutual Fire Insurance Company, as subrogee of Gary and Ramona Dyer, vs. Electrolux Home Products, Inc., Southern District of Indiana, Civil Action No.: 1:11-CV-1259, Warrenville, IL, February 26, 2013.

Allstate Insurance Company, as subrogee of John Clark, vs. Electrolux Home Products, United States District Court for the Northern District of Illinois, Eastern Division, Case No. 09 CV 6379, Geneva, Chicago and Geneva, IL, May 24 and August 28, 2012, April 22, 2013.

Marheine vs. Minergy LLC, ESI of Tennessee, et al., State of Wisconsin Circuit Court Winnebago County, Case No. 10-CV-0576, Atlanta, GA, April 27, 2012.

American Family Mutual Insurance Co., a/s/o John Power and Debra Doll-Power vs. Electrolux North America and Abt Electronics, United States District Court for the Northern District of Illinois, Case No. 1:10-CV-07864, Chicago, IL, April 11, 2012.

Rivers et al vs. Archer Daniels Midland Company et al., District Court of Garfield County, State of Oklahoma, Case No. CJ-07-29-01, Chicago, IL, January 6, 2012.

Illinois Farmers Insurance Company vs. Nicor Gas et al., Circuit Court for the Eighteenth Judicial Circuit, Du Page County, Illinois, Case No. 07 L 304, Wheaton, IL, June 21, 2011.

Nationwide Agribusiness Insurance Company vs. SMA Elevator Construction, Inc., et al., U.S. District Court for the Northern District of Iowa Central Division, Case No. 5:09-CV-04002, Chicago, IL, May 3 and July 25, 2011.

Ryan Goldstein et al vs. The Home Depot USA, Inc., United States District Court Northern District of Georgia, Case No. 1:08-CV-1825-CC, Chicago, IL, July 1, 2010.

Associated Milk Producers, Inc. vs. Sullair Corporation, et al., State of Minnesota in District Court, County of Brown, Fifth Judicial District, Case No. 08-CV-06-1140, Chicago, IL, May 26, 2010.

Paige Industrial Services, Inc. vs. The Harford Mutual Insurance Company, et al., Circuit Court for Anne Arundel County In and For the State of Maryland, Case No. C-08-132871, Lisle, IL, January 29, 2010.

American International Insurance Company of Puerto Rico, Inc. vs. Travelers Insurance Company, et al., United States District Court for the District of Puerto Rico, Case No. 08-02144, Wood Dale, IL, January 11, 2010.

Paige Industrial Services, Inc. vs. The Harford Mutual Insurance Company, et al., Circuit Court for Anne Arundel County In and For the State of Maryland, Case No. C-08-132871, Annapolis, MD, April 15, 2009.

Trial Testimony

Paige Industrial Services, Inc. vs. Weyers Floors, Inc., Circuit Court for Anne Arundel County In and For the State of Maryland, Case No. C-08-132871, Annapolis, MD, May 3–4, 2010.

Appendix C

Materials Considered

Materials Considered

As part of my analysis, I have reviewed and relied upon materials provided to me in this case, listed below, and on materials cited within this report. Where depositions or reports were provided with attachments or exhibits, those documents were also reviewed, even if not individually listed. In many cases, direct citations are provided in footnotes in the text; however, these footnotes are not necessarily my sole basis for the associated statements.

As discovery is continuing, additional materials may be generated and further analysis may be conducted. If additional opinions or alterations to the opinions stated in this report are generated, those opinions will be communicated to Brouse McDowell.

Client Supplied Materials

- All materials on the Wright Group supplied external hard drive, dated December 20, 2013

Depositions

- Blake, Scott – October 4, 2013
  - Transcript and Exhibit 1
- Broussard, Jeanne – September 18, 2013
  - Transcript and Exhibits 1-11
- Broussard, John – October 23, 2013
  - Transcript and Exhibits 1-3
- Christensen, Lisa – October 28, 2013
  - Transcript and Exhibits 1-9
- Cokain, Kevin – August 9, 2012
  - Transcript
- Donahue, Tammy – September 23, 2013
  - Transcript and Exhibits 1-8
- Donahue, Thomas – September 23, 2013
  - Transcript and Exhibits 9-11
- Droster, Judith – September 12, 2013
  - Transcript and Exhibits 1-9
- Freeman, Paul – October 22, 2013
  - Transcript and Exhibits 1-4
- Freeman, Shannon – October 22, 2013
  - Transcript
- Holt, Denise – November 12, 2013
  - Transcript and Exhibits 1-11
- Holt, William – November 12, 2013
  - Transcript and Exhibit 12
- Kucharski, David – September 30, 2013

    - Transcript and Exhibits 14-16
- Kucharski, Heather – September 18, 2013
    - Transcript and Exhibits 1-13
- Larson, Charles – September 12, 2013
    - Transcript and Exhibits 10-13
- Lenser, Pamela – September 27, 2013
    - Transcript and Exhibits 1-8
- Lewicki, Susan – August 9, 2012
    - Transcript and Exhibits 1-2
- McCants (Stephan), Linda – September 13, 2013
    - Transcript and Exhibits 14-21
- Santos, Frank – November 1, 2013
    - Transcript and Exhibits 1-7
- Starck-Johnson, Karen – October 3, 2013
    - Transcript and Exhibits 1-6
- Stephan, Dean – October 4, 2013
    - Transcript and Exhibits 1-6

Electrolux Production Documents

CSA Certification Documents

- Certificate of Compliance 112679, Certificate, January 16, 2009 (EHP LARSON 371153-371154)
- Certificate of Compliance Number 169808
    - Certificate, December 21, 2005 (EHP LARSON 2363702-263707)
    - Supplement (EHP LARSON 296468-296469)
- Certificate of Compliance Number 169808M, Certificate, January 25, 2005 (EHP LARSON 263696-263699)
- Certificate of Compliance Number 1023593
    - Certificates
        - March 3, 2004 (EHP LARSON 263816-263819)
        - July 12, 2005 (EHP LARSON 300878-300898)
        - July 8, 2008 (EHP LARSON 166489-166492)
        - September 16, 2008 (EHP LARSON 168858-168877)
        - September 16, 2009 (EHP LARSON 167213-167216)
        - March 23, 2010 (EHP LARSON 300874-300876)
    - Supplements and Reports (EHP LARSON 165766-165784, EHP LARSON 165801-165819, EHP LARSON 166146-166163, EHP LARSON 166493-166495, EHP LARSON 167189-167191, EHP LARSON 168858-168877, EHP LARSON 171822-171840, EHP LARSON 191592-191610, EHP LARSON 371174-371175, EHP LARSON 296488-296510)
- Certificate of Compliance Number 1126890
    - Certificate, May 7, 2007 (EHP LARSON 371162-371163)
    - Supplement (EHP LARSON 371181-371182)

- Certificate of Compliance Number 1126893, Supplement (EHP LARSON 371183)
- Certificate of Compliance Number 1126894
  - Certificate, March 8, 2007 (EHP LARSON 371164-371165)
  - Supplement (EHP LARSON 371184)
- Certificate of Compliance Number 1206759
  - Certificates
    - September 22, 2008 (EHP LARSON 354325-354327)
    - May 26, 2010 (EHP LARSON 371147-371149)
  - Supplements and Reports (EHP LARSON 165024-165043, EHP LARSON 165750-165765, EHP LARSON 165784-165800, EHP LARSON 165956-165972, EHP LARSON 168021-168037, EHP LARSON 190741-190989, EHP LARSON 172989-173003, EHP LARSON 190988-190989, EHP LARSON 371172-371173, EHP LARSON 296470-296487)
- Certificate of Compliance Number 1215905
  - Certificate, September 12, 2008 (EHP LARSON 371157-371159)
  - Supplement (EHP LARSON 371179)
- Certificate of Compliance Number 1216246
  - Certificate, September 5, 2008 (EHP LARSON 371160-371161)
  - Supplement (EHP LARSON 371180)
- Certificate of Compliance Number 1720147
  - Certificate, August 8, 2006 (EHP LARSON 371166-371167)
  - Supplement (EHP LARSON 371185)
- Certificate of Compliance Number 1730261
  - Certificate, July 28, 2006 (EHP LARSON 371168-371169)
  - Supplement (EHP LARSON 371186)
- Certificate of Compliance Number 2047937
  - Certificate, September 15, 2008 (EHP LARSON 371155-371156)
  - Supplement (EHP LARSON 371178)
- Certificate of Compliance Number 2127724
  - Certificates
    - March 6, 2009 (EHP LARSON 264407-264446)
    - October 26, 2011 (EHP LARSON 183186-183189)
    - November 7, 2011 (EHP LARSON 371143-371146)
  - Supplements and Reports (EHP LARSON 167848-167864, EHP LARSON 168277-168292, EHP LARSON 171805-171821, EHP LARSON 169702-169718, EHP LARSON 170271-170287, EHP LARSON 190717-190740, EHP LARSON 183447, EHP LARSON 173277-173295, EHP LARSON 175575-175593, EHP LARSON 176147-176165, EHP LARSON 176698-176716, EHP LARSON 177482-177511, EHP LARSON 180154-180173, EHP LARSON 190716, EHP LARSON 182201-182220, EHP LARSON 182331-182375, EHP LARSON 191620-191638, EHP LARSON 193042-193061, EHP LARSON 371311-371331, EHP LARSON 194979-194999, EHP LARSON 195009-195030)

UL Certification Documents

- Documents with Bates Numbers EHP LARSON 143192-143199; EHP LARSON 218164-218182; EHP LARSON 218531-218554; EHP LARSON 218619-218640; EHP LARSON 219247-219268; EHP LARSON 161588-161608; EHP LARSON 161662-161687; EHP LARSON 161726-161763; EHP LARSON 162290-162307; EHP LARSON 162308-162332; EHP LARSON 162333-162360; EHP LARSON 162361-162380; EHP LARSON 162926-162949; EHP LARSON 173319-173355

Dryer Design Documents

- Air Flow Diagram, Gas Dryers (EHP LARSON 057576)
- Air Flow Diagram, Electric Dryers.
- Dryer Model Prefixes and Sales Numbers
    - Spreadsheet of dryer model number prefixes differentiating gas and electrically heated dryers (Dryer Prefixes Highlighted For E and G.xlsx)
    - Spreadsheet of model numbers and brands (Dryer_ModelMaster_outbound_112113.xlsx)
    - Spreadsheet of unlocked sales data (EHP LARSON 280059)
- Dryer Testing Documents
    - Documents with Bates Numbers EHP LARSON 237362-252576
- Engineering Design Binders
    - Documents with Bates Numbers EHP LARSON 112789-118834; 236494-237342
- GE Project Record 97-0159
    - Documents with Bates Numbers EHP LARSON 262772-263190
- GE Test Protocol
    - Documents with Bates Numbers EHP LARSON 365480-365481
- Japanese Investigation
    - Documents with Bates Numbers EHP LARSON 380669-382302
- Ripley GE Test Protocols Binder
    - Documents with Bates Numbers EHP LARSON 276980-277275
- Willson Design Drawings and Part Number Historical Summary Spreadsheet
    - Documents with Bates Numbers EHP LARSON 279874-280059

Warranty and Claims Documents

- Litigation Claims Production List (EHP LARSON 012299-012435)
- Litigation Claims Production Spreadsheets (EHP LARSON 333924)
- Warranty Claims Production Spreadsheets (EHP LARSON 118836, EHP LARSON 382146-382171)

Plaintiffs' Production Documents

- Third Amended Complaint – May 13, 2013
    - 94-main
    - 94-1
    - 94-2

  - 94-3

- EHP Answers to 3rd Amended Complaint – July 25, 2013

Plaintiffs' Expert Reports

- Expert report of Chris W. Korinek
  - Insured: Broussard, September, 22, 2010
  - Insured: Kucharski, May 30, 2012
- David DeWolf
  - Inusred: Freeman, October 24, 2011
- Gregory St. Onge
  - Insured: Holt, May 9, 2009
- The Wright Group, December 20, 2013
  - Report and Appendix
    - Blake
    - Broussard
    - Donahue
    - Freeman
    - Holt
    - Kucharski
    - Larson
    - McCants
- Expert report of Joe Fallows and Sam Miller, December 20, 2013
  - Fallows Amended Appendix C

Documents Associated with a Specific Named Plaintiff

Blake

- BLAKE00000025-00000036
- BLAKE00000106-00000107
- BLAKE00000158-00000190
- BLAKE00000283-00000357
- EHP LARSON 281740-281802
- Adjuster Notes (BLAKE00000042-00000047; BLAKE00000110-00000157)

Brossard

- BROSS00001779-00001948
- BROSS00001950
- BROSS00002008-00002022
- BROSS00002051-00002103
- BROSS00002397-00002398
- BROSS00002734-00003513
- EHP LARSON 000033-000065

- Adjuster Notes (BROSS00002005; 002023-002047; 002654-00266 ; 00002671-00002733)

Donahue

- DONAHUE00000190-00000193
- DONAHUE00000197-00000199
- DONAHUE00000201
- DONAHUE00000204-00000207
- DONAHUE00000235-00000236
- DONAHUE00000242-00000251
- DONAHUE00000253-00000254
- DONAHUE00000264-00000275
- DONAHUE00000368-00000410
- DONAHUE00000582-00000583
- DONAHUE00000723-00000724
- DONAHUE00000999-00001024
- DONAHUE00001097-00001452
- EHP LARSON 281957-282028
- Adjuster Notes (DONAHUE00000742-00000745; DONAHUE00000748-0000049; DONAHUE00000780-00000782)

Freeman

- Dryer Documentation
    - 134431300es
    - 134763300esp
    - 134940700es
- FREEMAN00005979-00005986
- FREEMAN00006198-00006199
- FREEMAN00011929-00012027
- FREEMAN00012030-00012058
- FREEMAN00012097-00012386
- FREEMAN00012418-00012423

Holt

- HOLT000003
- HOLT000040-000051
- HOLT000188-000210
- HOLT000218-000220
- HOLT000222-000225
- HOLT000229-000232
- HOLT000240-000244
- HOLT000307-000347

- HOLT000440-000943
- EHP LARSON 282074-282128

Kucharski

- KUCHARSKI000001-000013
- KUCHARSKI000026-000030
- KUCHARSKI007009-007179
- KUCHARSKI007216-007768
- EHP LARSON 282129-282185

Larson

- LARSON000438- 000447
- LARSON000482-000484
- LARSON004044-004459
- LARSON004503-004812
- EHP LARSON 000001-000032
- Adjuster Notes (LARSON000001-000015; LARSON004460-004502)

McCants

- MCCANTS000670-000677
- MCCANTS000707-000720
- MCCANTS001269-001303
- MCCANTS001305-001898
- EHP LARSON 282186-282219

Other Materials Considered

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CPSC Documents

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Fire Statistics

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Appendix D

Detailed Report Addressing Plaintiffs' Design Defect Allegations

Thermal Sciences

Analysis of the Electrolux Ball-Hitch Clothes Dryer Design Defect Allegations Proposed by the Wright Group and Fallows Associates

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Exponent®
Failure Analysis Associates®

Analysis of the Electrolux Ball-Hitch Clothes Dryer Design Defect Allegations Proposed by the Wright Group and Fallows Associates

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Limitations

At the request of Brouse McDowell on behalf of Electrolux Home Products, Inc., Exponent conducted an investigation into and assessment of the design defect allegations made by the Plaintiffs in the matter of American Family Mutual Insurance Company, General Casualty Company of Wisconsin, Country Mutual Insurance Company, and Wisconsin Mutual v. Electrolux Home Products. Exponent investigated specific issues relevant to this matter as requested by Brouse McDowell. The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The findings presented herein are made to a reasonable degree of engineering certainty. We have made every effort to accurately and completely investigate all areas of concern identified during our investigation. If new data becomes available or there are perceived omissions or misstatements in this report regarding any aspect of those conditions, we ask that they be brought to our attention as soon as possible so that we have the opportunity to fully address them. I reserve the right to supplement this report and to expand or modify any opinions based on review of material as it becomes available through ongoing discovery and through any additional work.

Executive Summary

At the request of Brouse McDowell on behalf of Electrolux Home Products, Inc., Exponent conducted an investigation into and assessment of the design defect allegations made by the Plaintiffs in regard to fire safety of Electrolux-manufactured ball-hitch clothes dryers. This report was authored in regard to United States District Court for the Western District of Wisconsin, Case No.: 3:11-cv-00678 (SLC), captioned as American Family Mutual Insurance Company, General Casualty Company of Wisconsin, Country Mutual Insurance Company, and Wisconsin Mutual, Plaintiffs v. Electrolux Home Products, Defendant.

This report addressed the design defect allegations proposed by Mr. Ronald Parsons and Mr. Michael Stoddard of the Wright Group, Inc. (Wright Group) and Mr. Joe Fallows and Dr. Sam Miller of Fallows Associates (Fallows) in regard to Electrolux ball-hitch style dryers manufactured in Webster City, Iowa. Specific facts of each investigation are unique to that incident and must be considered during evaluation of the cause of a specific fire incident involving an individual clothes dryer. This report provided the background necessary to understand clothes dryers and the residual fire risk, and it evaluated the Wright Group's and Fallow's alleged design defects.

Regardless of the logical errors and inconsistencies in the Plaintiffs' consultants' uniform design defect allegations, they have routinely failed to demonstrate that the most likely cause of an individual fire involving a clothes dryer was uniquely consistent with their alleged defects. Furthermore, the factual differences between each specific dryer model and incident are significant, and the installation, operating environment, and individual use and maintenance history of each dryer will vary widely. The Plaintiffs have neglected to address the dominant role that these factors (e.g., venting) play in the likelihood of whether any dryer, Electrolux-manufactured or not, will be involved in a fire.

In many individual incidents, there is no supportive evidence of the Plaintiffs' allegation of lint accumulation behind the dryer drum prior to the fire. Instead, physical evidence is commonly either contradictory or supports a hypothesis of fire progression from the base into the air duct, which is contrary to the Plaintiffs' allegations, and is instead consistent with a failure to clean accumulated lint out of the cabinet coupled with inadequate exhaust venting over the life of the dryers.

The Plaintiffs' consultants have consistently ignored physical evidence and witness observations that contradict the Plaintiffs' uniform lint design defect hypothesis. More likely credible causes have been frequently dismissed in a clear application of expectation bias. Contributions of the installation, use and maintenance history, and the environment to which the dryers were exposed are also frequently ignored by the Plaintiffs' consultants. Although credible competing hypotheses can be developed to explain most fire incidents, there is commonly insufficient evidence to rule out multiple causes. Thus, the causes of individual fires should often be listed as undetermined, a conclusion which is consistent with good scientific fire investigation practice; however, the Plaintiffs' consultants opine that the fires were caused by design defects.

The Plaintiffs alleged that two design defects exist in Electrolux-manufactured ball-hitch clothes dryers: a uniform lint accumulation and ignition design defect and a plastic and fire containment design defect. Upon scientific examination, the bases, assumptions, and Plaintiffs' consultants' conclusions were readily shown to be based on the use of biased data sets, unfounded assumptions, and non-scientific conclusions. The Electrolux ball-hitch style clothes dryer is not a defective design and was designed in compliance with all applicable standards.

that these factors (e.g., cleaning and venting) play in the likelihood of whether any dryer, regardless of manufacturer, will be involved in a fire.

1.1 Plaintiffs' Allegation of Design Defects

Over the past two years, I have analyzed numerous ball-hitch clothes dryers manufactured by Electrolux at their Webster City, Iowa plant between 1999 and 2011 that were involved in fire incidents. I have examined approximately 60 clothes dryers in person, most with the Wright Group, and evaluated approximately 200 other clothes dryers from file materials provided by consultants in Electrolux cases. Although information regarding each dryer may have been incomplete (e.g., lack of use history, exhaust venting, fire discovery, etc.), it is clear that each incident is unique. The overall damage patterns may be similar within these dryers, but that similar appearance is a logical consequence of the nature of the appliance and fuels involved - lint, garment load, and plastic components—not evidence of a specific ignition and fire growth scenario.

From my review of the legal complaints and the reports of Mr. Parsons and Mr. Stoddard (Wright Group), and Mr. Fallows and Dr. Miller (Fallows), it is apparent that the Plaintiffs' consultants have alleged that almost all, if not every, fire involving an Electrolux clothes dryer was the result of a product design defect. Furthermore, they have based their design defect allegation upon the assumption that a specific fire scenario was the cause in all of these cases involving "ignition of accumulated lint behind the drum." Thus, they ignore potential fire causes due to other failure modes within a dryer and fire causes unrelated to their dryer design defect allegations.

The Plaintiffs' consultants also maintain that the ball-hitch dryers manufactured by Electrolux pose an unreasonable fire risk. The Plaintiffs' consultants do not acknowledge or address the obvious differences between lint deposits that may be found in gas versus electric heater pans. In the small sample set of used dryers in which any significant amount of lint accumulation is present in the heater pan, the deposits are different in size, density, and location based on the different configuration for gas versus electric heater pans. The Plaintiffs' consultants also fail to evaluate the use, installation, and maintenance of each dryer and fail to consider the complementary effects on lint accumulation (if any has accumulated) inside the dryer cabinet, the effects on heating system performance, and how these factors affect the overall fire risk in each appliance.

In dryers that caught fire and where lint had accumulated in the heater pan, which Plaintiffs' consultants use to support their defect theory,[7] the extent of lint deposit accumulations, the physical locations of the lint, and the extent of thermal damage to the lint vary widely. In this matter, few of the Plaintiffs' insureds' clothes dryers on which the Wright Group reported contain any evidence of sufficient, let alone excessive, pre-fire deposits of lint that could support the Plaintiffs' defect theory. Regardless, the Plaintiffs' consultants have consistently assigned the same cause—regardless of the more likely alternative causes that should have been considered in each case.

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7 The Plaintiffs have alleged that this design defect theory applies even to dryers with no significant lint accumulation in the heater pan, which is logically inconsistent with their arguments.

In this matter, the Plaintiffs have advanced two defect theories. I will summarize those theories and some of their most significant faults in the following sections in order to establish the terminology and concepts addressed in the remainder of the report.

1.1.1 Plaintiffs' Allegations of Uniform Excessive Lint Accumulation and Ignition Design Defect

Plaintiffs alleged that lint accumulates "behind the drum" in the heater pan and drum baffle, and that the resulting lint deposits are readily ignitable by the heating system. Plaintiffs' consultants' forced ignition tests and other referenced fire-involved dryers all contain an excessive quantity of lint in the heater pan or baffle behind the drum.[8] In this report I will refer to this excessive lint accumulation and ignition-based theory as the *uniform lint design defect* allegation for brevity. The interconnected parts of the defect allegation—excessive lint accumulation, ignition of a large enough quantity of lint to spread fire to a secondary fuel load (e.g., secondary deposits of lint downstream, clothing, or plastic components), and then lint-caused fire spread to a secondary fuel load—are more complex than the Plaintiffs' consultants have represented, and I will discuss this complexity throughout the report in order to provide the necessary elaboration where the Plaintiffs' consultants have not. This is a far-ranging design defect allegation that the Plaintiffs' consultants have based on excessive lint accumulation observed in some dryers and one of many hypothetical causes for clothes dryer fires. I refer to the alleged defect as a uniform lint design defect because the Plaintiffs' consultants have alleged that ball-hitch dryers manufactured by Electrolux at their Webster City, Iowa plant contain this lint accumulation defect regardless of the specific model, heating system type, or variations in the installation, use, and cleaning of each dryer.

The Plaintiffs' consultants' uniform lint design defect allegation is the same allegation that the Wright Group[9] has proposed in numerous past individual dryer fire incident investigations. This defect allegation has several parts:

1. Lint accumulates in the heater pan behind the drum, or lint accumulates in between the drum baffle and the back wall of the drum.
2. Lint accumulates in the front plastic air duct and blower housing.
3. Lint behind the drum is somehow ignited.
4. Burning lint embers (sometimes described as a single ember) are pulled through the drum.
5. Burning lint embers ignite downstream lint
    a. In the front air duct, or
    b. In the blower housing.

The Plaintiffs' consultants' alleged ignition and fire growth scenario is vague; it does not describe how, where, or why the accumulated lint was ignited during a subject incident in such a way that the scenario can be tested. The fire growth scenario may skip past the drum load, as in most of the named Plaintiffs' dryers. Ignition of the drum load is not a necessary step in the

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8 Wright Group report, dated December 20, 2013 and Wright Group hard drive produced December 20. 2013

9 Mr. Stoddard and Mr. Ronald Parsons are the lead investigators at the Wright Group who have alleged this uniform lint accumulation and ignition design defect in numerous past cases.

Wright Group fire scenario; they hypothesize that burning embers bypass the load and instead ignite downstream lint in the air duct or blower housing. This hypothesized jump past the tumbling drum load in the ignition sequence, although not consistent with the logical fire dynamics or testing experience, is often a necessary assumption for their hypothesis to accommodate witness observations during the discovery of the fire. This assumption is necessary because in cases where the witness opens the dryer door, they commonly report that the load was not burning or fire-damaged when they discovered the fire. Witnesses commonly report seeing flames or smoke coming from the lint grill at the front of the drum, but they do not see flames or smoke elsewhere in the drum or behind the drum. Since the fire is witnessed only peripherally at the early stages, an investigator must draw an inference regarding the first fuel ignited and fire growth scenario based on experience and fire dynamics. Thus, the Wright Group consistently infers that the burning embers have bypassed the load and lint screen, a process which is inconsistent with the logical progression of fire growth and fire growth demonstrated through their testing.

In investigations of fires involving clothes dryers other than Plaintiffs' units, the Wright Group also commonly fails to consider the effects of each dryer's specific installation, exhaust system, use, and cleaning history as being relevant to the alleged accumulation and ignition of lint. The Wright Group has taken the same approach to the investigation of the insureds' dryer fires in this matter—that is, the Wright Group conspicuously dismisses any association between fire cause and installation, exhaust system, and consumer usage and care circumstances in each case. Instead, they describe the physical features of the design defect as being lint accumulated in the heater pan, baffle ring, and front air duct.

The Plaintiffs further allege that lint behind the drum is not visible to and cannot be cleaned out by the user. These same observations can be applied to every clothes dryer in the market, not just Electrolux-manufactured dryers. I am not aware of any clothes dryer models that are constructed such that the consumer can view the inside of the cabinet and observe accumulated lint. Further, all clothes dryers must be disassembled to access the mechanical areas in order to clean combustible lint out of the cabinet. Manufacturers do not intend for the user to perform this service activity; thus, just as in Electrolux manuals, other manufacturers also suggest that an authorized service technician perform this work. This observation is common to all manufacturers' clothes dryers and is not a basis for concluding that the Electrolux design is defective.

The defect allegation requires the Plaintiffs' consultants to selectively choose the same potential fire ignition and growth scenario in every dryer fire incident. However, this approach is not consistent with good scientific practice for fire investigations. Proper application of the scientific method to each fire incident may identify several competing hypotheses that are consistent with the facts, physical evidence, and logical fire growth scenarios. However, the Plaintiffs' consultants have uniformly concluded that the damage to the front plastic air duct and blower housing caused by a fire incident, although each part experienced different levels of damage in different dryers, is evidence of their selective fire growth hypothesis and that the use of certain plastic components also constitutes a design defect.

1.1.2 Plaintiffs' Allegation of a Combustible Plastic and Fire Containment Defect

The Plaintiffs' second allegation is that Electrolux's use of a HB-rated plastic air duct and blower housing components constitute a design defect. They claim through the reports of Mr. Parsons and Mr. Stoddard, and Mr. Fallows and Dr. Miller, that HB plastics caused fires to grow inside clothes dryers and to escape the cabinet. From my experience and a review of the discovery documents, their allegations are not scientifically supported and are mere speculation. These allegations are based upon the specific alleged lint accumulation defect and resulting fire cause scenario, which are not commonly supported in individual incidents or the rest of the population of fire incidents.

The Plaintiffs claim that changing two components, the front air duct and blower housing, from HB-rated plastic to another, more fire-resistant plastic material would prevent internal fires from growing and escaping the dryer cabinet. However, they have provided no testing, fire dynamics analysis, or other reasonable basis for this conclusion. An accidental fire inside a clothes dryer can be ignited for many reasons, but the ultimate growth of a fire is related to the internal fuels and combustion in a confined environment. The potential for an individual clothes dryer to contain any internal fire is dependent upon many aspects of its construction, installation, cleaning, heating system type/configuration, garment load, user interaction, and the fire scenario itself—beyond simply the use of a certain type of plastic in a component part. The Plaintiffs have not demonstrated that changing the composition of any plastic components will reduce or eliminate the frequency or severity of fires involving Electrolux-manufactured ball-hitch dryers let alone any other manufacturer's dryer design.

The goal of designing a clothes dryer for containing model base, drum, or other types of fires is more challenging than the Plaintiffs' consultants have suggested. Until recently, there was no uniform standard test protocol for fire containment tests. The first such test protocol was published in March 2009 and was required for UL-listing of clothes dryers in March 2013. As a consequence, fire containment potential for all clothes dryers was variable and not uniformly quantifiable throughout prior to 2013.

In this report, I will address the Plaintiffs' claims regarding their seemingly simple like-for-like swap of plastics, the complexity of fire containment in a clothes dryer, and the reasonableness of Electrolux's decision to continue using HB-rated plastic in their dryer designs.

1.2 Scope of the Report

This report summarizes my investigation, analysis, and findings regarding the background material on clothes dryers and an analysis of the Plaintiffs' consultants' alleged defect claims. The background material comprises information on clothes dryer operation, voluntary product safety standards, lint production and accumulation, and exhaust systems. I also discuss scientific methodology for fire investigation along with an analysis of common clothes dryer fire causes, dryer testing, and analysis of the hypothesis posed by the Plaintiffs' consultants.

I present a discussion on the fire risk associated with clothes dryers both in general and for Electrolux-manufactured dryers. I outline the errors and omissions in the Plaintiffs' consultants'

fire risk analyses. The Plaintiffs' combustible plastic claim is analyzed and placed in context of the overall laundry industry. I also discuss the combustibility of plastics, their effects on fire containment, and the applicability of fire tests to dryer design.

2 Clothes Dryer Background

An understanding of the operation and design of clothes dryers is required to adequately analyze plausible fire causes within a clothes dryer. In this section, I will address global factors pertaining to clothes dryer operation and lint issues that affect dryers produced by all manufacturers. I will explicitly state those instances where my analysis pertains specifically to Electrolux-manufactured ball-hitch dryers. A clothes dryer is a heat-producing device used to evaporate water from laundered garments. Vented clothes dryers use one of two types of heat sources to dry the garment load—either a gas-heated burner system or an electrical resistance heater system. Non-vented or condenser dryers utilize a heat exchange system to remove moisture from garments but only represent a small part of the U.S. market and are not at issue in the Plaintiffs' claims. Clothes dryers included in these claims are vented (as opposed to condensing), using either gas or electricity for heat; thus, I will only discuss vented clothes dryers in the rest of the report.

The following sections will provide an overview of the operational features of clothes dryers and applicable safety standards. The significance of lint in clothes dryers and the relationship to adequate exhaust installation and maintenance will then be discussed.

2.1 Overview of Clothes Dryer Operation

Although the basic principles of operation and removal of moisture from clothing are similar in most household clothes dryers, different manufacturers' units and individual models from a manufacturer vary according to their specific control features, airflow patterns, heating elements, and safety features. Clothes dryers heat an incoming air stream that is pulled through the tumbling wet garment load by a motor. The unit's motor directly spins an internal blower to induce airflow and uses a belt to rotate the drum to tumble the garments. Moisture-laden air from the drum is pulled through a lint screen, which captures lint liberated by the drying process. The blower discharges moisture-laden air containing entrained lint particles, not captured by the lint screen, through an internal rigid duct. The clothes dryer exhaust system then transitions to the permanent exhaust system in the residence.

Clothes dryer manufacturers design and build various dryer models with variations in controls, features, and internal components. Manufacturers typically refer to base models as "platforms," which may have several design differences such as the control interface, drying options, and colors. From a review of the discovery documents, Electrolux (and precedent companies) have developed several dryer platforms. Within the U.S. market, two general styles of clothes dryer platforms were distributed during the early 2000s—the heater pan-style (including the Electrolux platforms) and bulkhead style platforms. The pan-style dryer typically has a center-supported drum with a perforated rear wall attached to the drum. These are also referred to as "ball-hitch" style dryers due to this support bearing assembly. Heat passes through a stationary vertical pan behind the drum, and then through the rear perforated wall into the interior of the drum. The bulkhead style typically has a circumferentially supported drum (i.e., the cylindrical portion of the drum rests on roller bearing supports), and the rear wall is stationary and not

attached to the drum. Heat passes through an air inlet opening in the rear stationary wall (e.g., "bulkhead") then into the interior of the drum.

The Electrolux pan-style platform was marketed primarily under the brands White-Westinghouse, Frigidaire, Sears Kenmore, and GE Profile during the early 2000s, as well as Gibson, Crosley, or Hotpoint, for example. The Electrolux clothes dryers produced from the 1960s until 2011, with the latter decades manufactured at the Webster City facility, were configured with a heater pan behind the drum. The Portland and Tempest platforms are configured as bulkhead style with production occurring in Juarez, Mexico. Based on deposition testimony, the reason for introducing bulkhead configuration dryers is market-based.[10] By using this configuration, the drum capacity was increased without changing the outer cabinet size.

Within the heater pan dryers, the air flow dynamics are significantly different between gas-heated and electrically-heated dryers. Both configurations rely upon the blower fan to pull air past the heater, through the drum, then through the front air duct. Simplified schematics are provided in Figure 1 and Figure 2. From these simplified schematics, the significant difference between the two configurations in air flow through the heater pans is not obvious. The Plaintiffs have not addressed the significant differences in airflow or the differences in lint accumulation for improperly vented clothes dryers. I will address the lint accumulation considerations later when I am addressing the Plaintiffs' uniform lint design defect allegation. First, I will describe the normal airflow pattern through the heater pan for properly vented gas-heated and electrically-heated clothes dryers.

The gas-heated system uses a sealed duct arrangement to pull air past the burner, through the heater pan, and into the rear of the drum. This system is configured to limit air leakage into the heater pan, thus maintaining sufficient draft past the burner flame to allow stable burner performance. Air enters the heater pan vertically, through the rectangular duct, oriented on the left side as indicated on the graphic by the arrows in Figure 3. The air then travels circumferentially around the pan in a circular fashion while also being pulled through the rear wall of the drum. This path of airflow is created by the sealed pan configuration. Two drum configurations were produced during the early 2000s; the early units did not use a baffle ring on the rear wall of the drum. Later units after 2005 used this baffle ring.[11] The baffle ring will serve to channel air into the center area of the back wall of the drum.

In contrast, the electrically-heated clothes dryers do not employ a sealed pan. These heater pans are designed to direct air radially into the pans across the heating element as depicted in the right graphic in Figure 3. The pans also have holes in the back wall, which allow air flow to enter the back side of the pan. These heater pans are open to the base area of the dryer where the gas heater pans are not. The electrically-heated dryer drums always contained a baffle ring during the early 2000s.[12] The radial airflow pattern is significantly different from the gas heater pans. As a consequence, lint deposition if it occurs is different between gas-heated and electrically-heated clothes dryers. I will discuss these differences and their effects on the

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[10] Deposition of Brian Ripley, March 14, 2013, page 28.

[11] Deposition of Carl King, September 6, 2013, Exhibit 167, page 3.

[12] Deposition of Carl King, September 6, 2013, page 96.

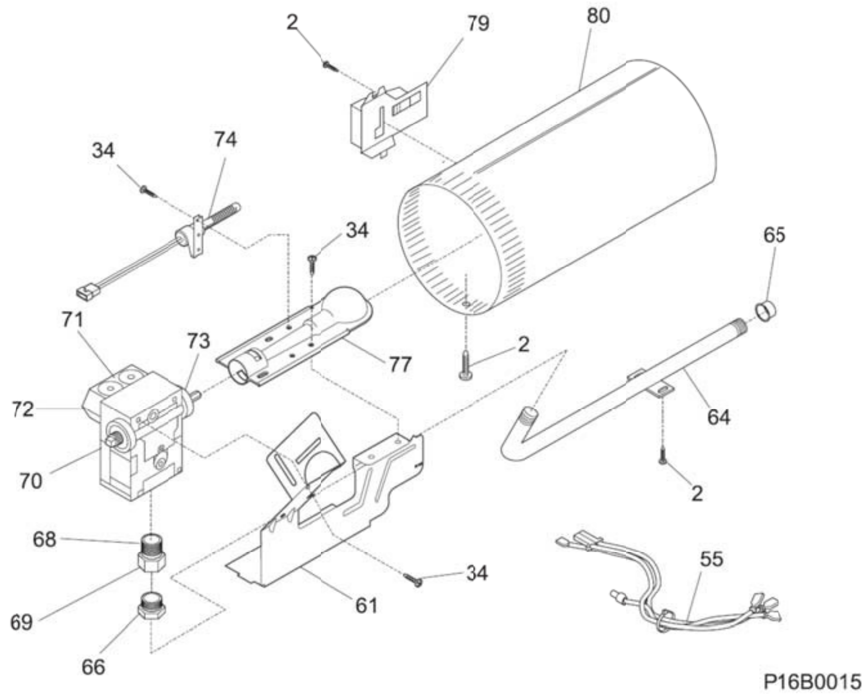
The typical high-limit thermostat setting for a gas-heated dryer is 180°F with a resetting temperature of 140°F, and it is 260°F with a reset point of 190°F for electrically-heated dryers. The various moisture and temperature sensors used will have an effect on the operation, efficiency, and potential failure modes of an individual dryer. If the temperature rises higher in this area, for example, due to overheating with a failed high-limit thermostat, the non-resettable thermal limiter will disable the dryer heating system in electrically-heated units. Gas-heated units do not typically contain a thermal limiter. This thermal limiter is non-resettable meaning that it must be replaced to operate the dryer if it has tripped.

Some models are equipped with moisture control functions that influence the advancement of the timer switch and control of heating. An individual drying cycle may be controlled to heat, if necessary, or to tumble without heating depending upon the setting and the control features.

2.1.2 Gas-Heated Versus Electrically-Heated

The most obvious difference that may exist between any two given dryers is the heat (or fuel) source, which may be either a fuel gas or electricity. The type of heating system often dictates a different installation location within the dryer cabinet and subsequently, differences in the internal airflow system and controls.

Gas burner systems use either natural gas or propane gas at household pressure with the significant burner differences being the orifice size (e.g., 44 for natural gas and 55 for propane gas) and the burner mixing chamber's air shutter position. The fuel gas is ignited in a combustion chamber and the heated air is used to dry the garment load. In Electrolux gas dryers, the gas burner system is mounted at the base of the cabinet. An example parts schematic is shown in Figure 4.

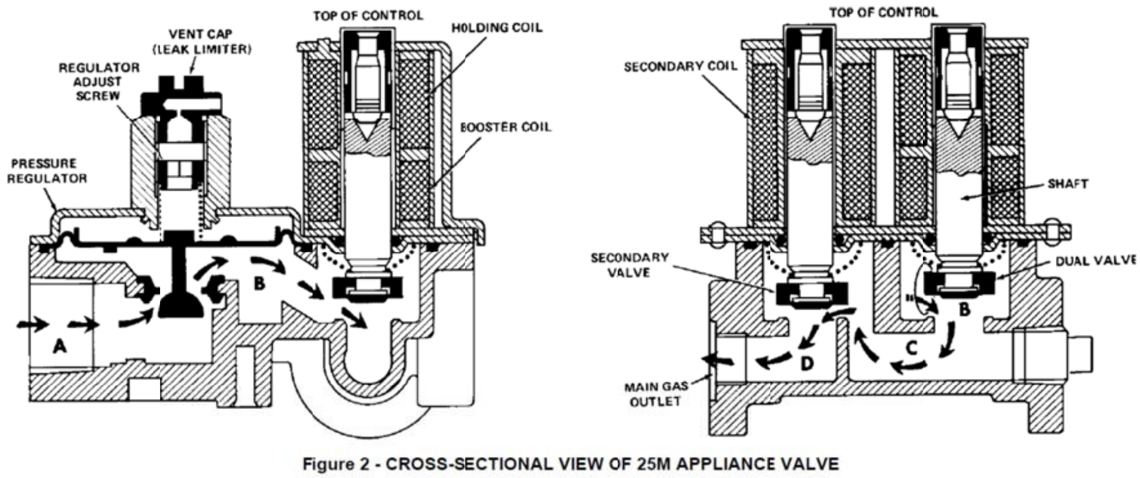


Frigidaire Factory Parts Catalog corresponding to Product No. FGQ1442ES0, Publication No. 5995431201, May 3, 2010

Figure 4. Example "ice-cream scoop" style gas burner system from a Frigidaire Factory Parts Catalog corresponding to Model Number FGQ144ES0 gas heated dryer.

The gas flow is controlled by a gas valve assembly (components 70-73 in Figure 4). A representative diagram of the gas valve assembly is shown in Figure 5, which consists of three primary components: a pressure regulator, a primary (or booster) coil and a secondary coil. The pressure regulator is typically preset for natural gas, and the regulator adjustment screw is changed to match the pressure for LP service. The regulator dictates the gas pressure, and the coils (or solenoids) control whether the gas can flow into the combustion chamber. If the coils are energized, gas can flow out of the orifice and into the burner (component 77 in Figure 4). In the burner, the air flows past an air shutter and toward the hot surface igniter (component 74 in Figure 4). The air shutter allows air to mix with the gas prior to ignition. Proof of ignition is monitored by a radiant sensor mounted at the side of the combustion chamber (component 79 in Figure 4).

Gas-heated dryers have safety controls not present in electrically-heated dryers. The gas valve assembly has a leak limiter, or a very small hole in the vent cap, which should allow a small gas leak in the event of a pressure regulator leak. There are two coils in series in the gas valve assembly that provide safety through redundancy. If the radiant flame sensor does not detect a flame, it interrupts current to the solenoids and stops gas to the burner.



White-Rodgers 25M Series Gas Controls Product Information, R-4080, Page 5.

Figure 5. Diagrams indicating principle of operation for gas valve in the clothes dryer.

Residential electrical dryer heater systems in the U.S. typically use a 240 V single phase power supply. In Electrolux electrically-heated dryers, the heating element coil is mounted at the rear of the cabinet in a pan, as shown above in Figure 2. As indicated earlier, the air flow patterns through electric heater pans are different from those in gas dryer heater pans due to the different heating system arrangement. Air is drawn through the pan over resistance heating coils (or the heating element) and then through the garment load.

2.2 The Status and Applicability of Voluntary Product Safety Standards

Consensus standards are compiled with the input of manufacturers, designers, regulators, and other safety experts. These standards are intended to establish minimum safety requirements for a product, or practice (via either *prescriptive* requirements or *performance* based criteria). Thousands of consensus standards exist today that apply to many of the products available in the consumer marketplace. Frequently, these documents are adopted by law and become mandatory. In other instances, these standards are voluntarily complied with to promote product safety. Compliance with these voluntary safety standards can constitute one element of a manufacturer’s product safety program. Although voluntary safety standards are not included in the legal code, many of them are generally accepted as an established standard of care. Voluntary standards and manufacturers’ product safety programs are intended to reduce the residual risk posed by appliances because many types of appliances, including clothes dryers, contain inherent risks that cannot be eliminated without also eliminating the utility of the appliance.

For clothes dryers, the voluntary safety standards are jointly administered and harmonized by Underwriters Laboratories (UL) and the Canadian Standards Association (CSA). These standards are also accredited by the American National Standards Institute (ANSI). UL, primarily, maintains the electrically-heated clothes dryer standard, *UL/ANSI 2158 Electric*

Clothes Dryers, and CSA, primarily, maintains the gas-heated clothes dryer standard, *ANSI Z21.5.1-2002/CSA 7.1-2002, Standard For Gas Clothes Dryers, Volume l-Type 1 Clothes Dryers*. These standards specify numerous safety requirements and design verification tests for clothes dryers. Additionally, these standards require individual component parts to meet other standards.

The following includes a complete list of referenced standards from UL/ANSI 2158 2009 and from ANSI Z21.5.1 2002 that clothes dryers must meet to be listed. Many of these standards classify the fire performance of plastics that are used in construction of dryers. UL 94 is one of those standards. The components and subsystems within each dryer design must also meet these referenced standards.

Harmonized UL/CSA Electric Clothes Dryer (UL 2158, 2009, 2nd Ed.)[13]

- CAN/CSA-B64.1.1-94, Vacuum Breakers, Atmospheric Type (AVB)
- C22.1-94, Canadian Electrical Code, Part I
- CAN/CSA-C22.2 No. 0-M91, General Requirements – Canadian Electrical Code, Part II
- C22.2 No. 0.1-M1985 (R1994), General Requirements for Double-Insulated Equipment
- C22.2 No. 0.2-93, Insulation Coordination;
- C22.2 No. 0.5-1982 (R1992), Threaded Conduit Entries;
- C22.2 No. 0.15-95, Adhesive Labels;
- CAN/CSA-C22.2 No. 0.17-92, Evaluation of Properties of Polymeric Materials;
- C22.2 No. 14-95, Industrial Control Equipment;
- C22.2 No. 24-93, Temperature-Indicating and -Regulating Equipment;
- C22.2 No. 55-M1986 (R1992), Special Use Switches;
- C22.2 No. 66-1988, Specialty Transformers;
- C22.2 No. 77-95, Motors with Inherent Overheating Protection;
- CAN/CSA-C22.2 No. 100-95, Motors and Generators;
- C22.2 No. 156-M1987, Solid-State Speed Controls;
- C22.2 No. 169-97, Electric Clothes Washing Machines and Extractors
- CAN/CSA-C22.2 No. 223-M91, Power Supplies with Extra-Low-Voltage Class 2 Outputs;
- CAN/CSA-C361-92, Test Method for Measuring Energy Consumption and Drum Volume of Electrically Heated Household Tumble-Type Clothes Dryers.
- UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances;
- UL 157, Gaskets and Seals;
- UL 244A, Solid-State Controls for Appliances;
- UL 506, Specialty Transformers;
- UL 508, Industrial Control Equipment;
- UL 514A, Metallic Outlet Boxes;
- UL 519, Impedance-Protected Motors;
- UL 547, Thermal Protectors for Motors;

[13] Excerpted from Section 3.2 Reference publications, "UL Standard for Safety for Electric Clothes Dryers," UL 2158-2009/CSA-C22.2 No. 112-97, Underwriters Laboratories, Second Edition, March, 2009.

- UL 723, Tests for Surface Burning Characteristics of Building Materials;
- UL 746A, Polymeric Materials – Short Term Property Evaluations;
- UL 746C, Polymeric Materials – Use in Electrical Equipment Evaluations;
- UL 746E, Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fiber, and Materials Used in Printed Wiring Boards;
- UL 840, Insulation Coordination Including Clearances and Creepages Distances for Electrical Equipment;
- UL 873, Temperature-Indicating and -Regulating Equipment;
- UL 969, Marking and Labeling Systems;
- UL 991, Tests for Safety-Related Controls Employing Solid-State Devices;
- UL 1004, Electric Motors;
- UL 1054, Special-Use Switches;
- UL 1097, Double Insulation Systems for Use in Electrical Equipment;
- UL 1585, Class 2 and Class 3 Transformers;
- UL 2157, Electric Clothes Washing Machines and Extractors.
- ANSI MC 96.1-1982, Temperature Measurement Thermocouples;
- ANSI/ASSE 1001-1988, Pipe Applied Atmospheric Type Vacuum Breakers;
- ANSI/ASSE 1007/AHAM HLW-2PR-1986, Plumbing Requirements for Home Laundry Equipment;
- ANSI/NFPA 70-1993, National Electrical Code.

ANSI Z21.5 2002

- ANSI Z223.1-1999/NFPA 54-1999. National Fuel Gas Code
- ANSI C101.1-1992, Leakage Current for Appliances
- ANSI Y14.15-1966 (R1988), and Supplements Y14.15a-1971,Y14.l5b-1973, Electrical and Electronics Diagrams
- ANSI/ASME Bl.20.1-1983 (Rl992), Pipe threads, General Purpose (Inch)
- ANSI/ASME B36.10M-1996, Welded and Seamless Wrought Steel Pipe
- CSA C22.1-2001, Canadian Electrical Code
- CSA C22.2 No. 3-1988 (R1993), Electrical Features of Fuel-Burning Equipment
- CSA C22.2 No. 24, Temperature Indicating and Regulating Equipment
- CSA C22.2 No. 199-1989 (Rl994), Combustion Safety Controls and Solid State Igniters for Gas and Oil Burning Equipment
- CSA Z240 MH Series MH-86 (Rl992), Mobile Homes
- CSA 6.3-2000 • ANSI Z21.18-2000, Gas Appliance Pressure Regulators
- CSA 6.5-2000 •ANSI Z21.21-2000, Automatic Valves for Gas Appliances
- CSA 6.20-2000 •ANSI Z21.78-2000, Combination Gas Controls for Gas Appliances
- CGA 9.1-M97 •ANSI Z21.15-1997, and Addenda CGA 9.la-2001 •ANSI Z21.15a-2001, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
- CAN1-6.4-M79 (Rl996), Automatic Gas Ignition Systems and Components
- CAN1-6.6-M78 (Rl996), Gas Appliance Thermostats
- CSA B149.1-2000, Natural Gas and Propane Installation Code

- Manufactured Home Construction and Safety Standard, Title 24 CFR, Part 3280 [formerly the Federal Standard for Mobile Home Construction and Safety, Title 24, HUD (Part 280) 1975]
- ANSI/IEEE 315-1975 (R1994), and Supplement, ANSI/IEEE 315A-1986, Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Class Designation Letters)
- ANSI Z21.20-2000, Automatic Gas Ignition Systems and Components
- ANSI Z21.23-2000, Gas Appliance Thermostats
- ANSl/NFPA 70-1999, National Electrical Code
- ANSl/NEMA WD6-1988, Wiring Devices - Dimensional Requirements

Electrolux-manufactured ball-hitch dryers were UL-listed and CSA-listed when the Plaintiffs' dryers were manufactured; thus, they complied with the voluntary standard requirements.[14] The Plaintiffs have provided no basis for disputing their compliance with the voluntary standards.

2.3 Lint Considerations

Garment use and the laundering processes cause wear to garment fabric and ultimately create lint. As garments are dried and tumbled, garments shed lint which is then carried by the airflow through the drum of the clothes dryer. Lint composition and rate of generation are generally dependent upon the garment fabric, fabric treatments, age/use history, washing operation, and drying temperature. Most liberated lint entrained in the drum airflow is captured by the lint screen or discharged through the exhaust ducting. During normal operation, small quantities of lint may leak from the drum, internal air ducts, or exhaust system, or they may be drawn into the clothes dryer cabinet from the outside, and subsequently deposit in the dryer cabinet. To be leaked, these lint particles must be small enough to pass through the lint screen (i.e., when caked with lint), leak past seals, and not remain suspended in the low velocity airflow within the cabinet. These lint particles are generally dust particles, single fibers, or small clumps of a few fibers. Lint accumulates in all dryers through normal usage, and occurs because of many factors specific to each dryer including the following: composition of loads, number of drying cycles, exhaust venting, user interaction, washing machine effects, and the individual clothes dryer itself.

The consumer's or other user's choosing not to remove (clean) accumulated lint from inside a clothes dryer is not uncommon and is represented as the leading cause of fires involving this type of appliance.[15,16] Manufacturers' maintenance instructions for clothes dryers typically prescribe periodic internal cabinet cleanings (specifically, every 18 months for Electrolux

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[14] For example, CSA Certificates of Compliance for Dryer Models at issue: EHP LARSON 112695-112702; UL Certificate of Compliance for Larson Dryer: EHP LARSON 000033, UL Certificate of Compliance for Dryer Models at issue EHP LARSON 112694, UL/CSA Certificates of Compliance: EHP LARSON 252577-252711.

[15] "Home Fires Involving Clothes Dryers and Washing Machines," NFPA USS57, 2012.

[16] "Clothes Dryer Fires in Residential Buildings (2008–2010)," Topical Fire Report Series, United States Fire Administration, 13(7), August 2012.

clothes dryers).[17] The obvious reason for this instruction is to remove potential lint accumulations before they grow to a size that could pose a fire hazard. Electrolux (or its precedent companies) have used this warning since the 1970s.[18] UL/ANSI 2158 has required this type of warning in the instructions for UL-listed electrically-heated clothes dryers since its first edition in 1994.[19] Electrolux and other manufacturers prescribe this same cleaning instruction for gas-heated dryers even though gas-heated dryers are listed under ANZ Z21.5.

All vented clothes dryers, regardless of manufacturer and including both heater pan-style and bulkhead style clothes dryers, contain lint and exhibit the characteristics discussed above. Typically, clothes dryer manuals, regardless of manufacturer, instruct the owner to have an authorized service provider periodically (e.g., every 12 to 24 months) clean the cabinet of lint to limit potentially hazardous accumulations of lint. Because of user and installation variation, it is impossible to develop an accurate prediction method for lint accumulation rate in a specific clothes dryer. I will discuss and enumerate these use and installation variables later in this report.

A small residual fire risk is inherent to all manufacturers' clothes dryers because all dryers use a heat source and contain a potential fuel (i.e., clothes load and lint). Consequently, manufacturers design clothes dryers to meet safety standards, including safeguards to prevent unsafe operating conditions, and providing instructions to mitigate the inherent residual fire risk (e.g., UL2158 and ANSI Z21.5). I will discuss the residual fire risk posed by all clothes dryers and compare that to Electrolux-manufactured clothes dryers in later sections.

2.4 Clothes Dryers' Exhaust Venting

A clothes dryer exhaust system consists of three distinct sub-systems: the manufactured internal ducting and blower, the external transition duct between the clothes dryer and the permanent exhaust ducting, and the permanent exhaust ducting in the home. Figure 6 below illustrates the flow of air from a generic clothes dryer through the exhaust system. The exhaust system is intended to convey warm, humid air and residual lint particles out of the clothes dryer and out of the residence. A blocked or restricted exhaust system will prevent normal operation of a clothes dryer, can cause overheating of the unit, and may lead to accelerated lint accumulation inside the dryer.

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17 Examples - Whirlpool Dryer User Instructions, P/N W10287573A, September 2009; GE Profile Dryer Owner's Manual and Installation Instructions, DPGT750, December 2005; Maytag Dryer Use & Care Guide, Part No. 2206672, 2006; Electrolux Use & Care Guide, P/N 134674100B (0806).

18 Deposition of Carl King, March 26, 2013, page 112.

19 "UL Standard for Safety for Electric Clothes Dryers," UL 2158-1994/CSA-C22.2 No. 112, Underwriters Laboratories, First Edition, January 1994, page 26.

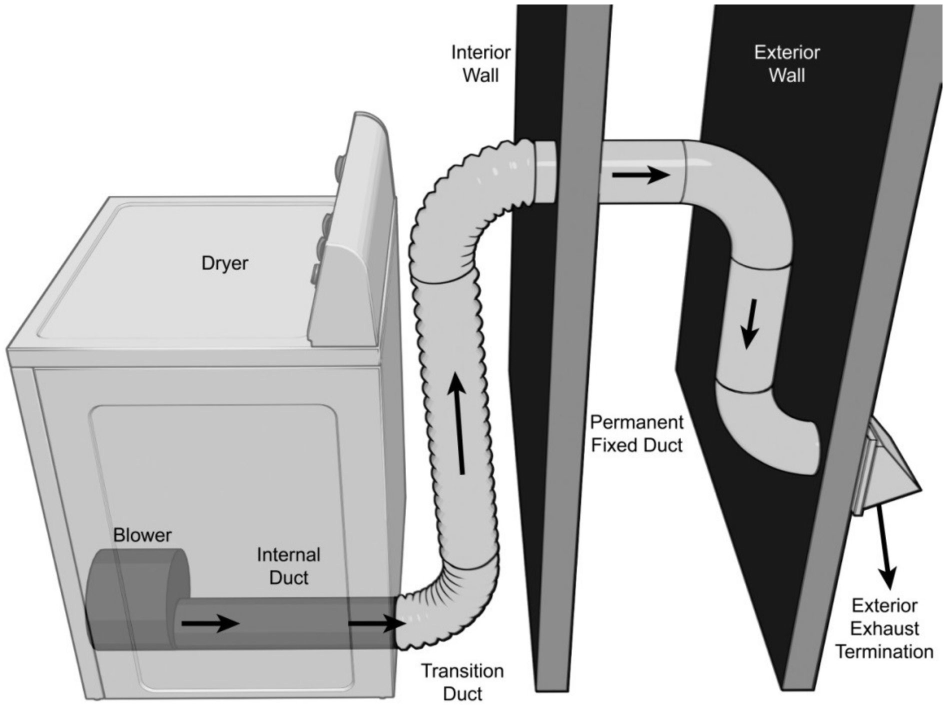

Figure 6. Schematic of a typical clothes dryer exhaust system.

The internal air ducting is part of the engineered clothes dryer system and should be reasonably consistent from unit to unit of the same design depending upon wear history and slight differences in individual unit assembly. However, the permanent (fixed) ducting installed in the residence is unique to each residential installation, and is outside the control of the dryer manufacturer. The permanent exhaust system will exert dominant effects on the overall performance of the system and lint accumulation within the clothes dryer over time (assuming that the transition duct is installed properly). Clothes dryer manufacturers provide installation instructions and guidelines for transition ducts and permanent exhaust systems based on the particular features of each appliance.

The Plaintiffs have claimed that Electrolux-manufactured clothes dryers will collect lint behind the drum in a manner that unreasonably increases the dryer's fire risk; however, they have done nothing to demonstrate that excessive lint accumulations noted in some clothes dryers are not due to improper installation of exhaust ducting. Improper venting and lack of cleaning by an authorized servicer may lead to potentially hazardous accumulations of lint inside an individual dryer cabinet during the life of the product. The Plaintiffs have not demonstrated that properly installed and maintained Electrolux-manufactured clothes dryers will have an increased fire risk over the background population of other manufacturers' clothes dryers.

2.4.1 Permanent Exhaust System

Each permanent exhaust system will be unique to a residence because, for example, the number of bends, the internal roughness, the length and other geometrical factors, history of use, history of cleaning, and exterior termination. In addition to the exhaust system, the environment surrounding the dryer, depending on the room of installation and layout for the residence, can

also affect the performance of the exhaust system. The long term safe operation of a clothes dryer requires an adequate exhaust system.

The proper installation and adequate ventilation of the entire clothes dryer exhaust system can influence the risk of a potential fire during the life of a clothes dryer. Factors that affect the adequacy of clothes dryer ventilation include the configuration, construction, and installation of the exhaust system and components; the usage history of the clothes dryer; and the maintenance of the system.

Excessively long duct runs and elbows, high frictional resistance in the ducting, leaks from the ducting, damage to the ducting, obstructions or buildup in the ducting, and lack of make-up air to the appliance all reduce exhaust ducting performance. These factors are not exclusively related to a specific portion of the exhaust system (e.g., the transition duct, permanent exhaust duct, exterior draft hood) nor are they completely dependent on the particular type of component installed. Improper installation or maintenance of any portion of the exhaust system may adversely impact the airflow and thereby lint accumulation.

2.4.2 Transition Ducts

Whereas permanent exhaust systems may remain fixed in place at a residence throughout the use of multiple clothes dryers, transition ducts are temporary and get replaced from time to time. Improper transition duct installations manifest themselves in a number of ways. Failing to size the transition duct appropriately, i.e. using excessively long duct runs, is one manner of improper installation. Another improper installation is a failure to properly seal ducting joints (typically with duct tape), thus allowing air leaks out of the system. A leaky exhaust system may allow airborne lint to escape the exhaust system near the air intake to the dryer and thus be drawn back into the dryer cabinet. Transition ducts often pose a challenge for installation and maintenance because of the orientation and distance between the dryer exhaust and the fixed permanent exhaust connection and limited access behind the dryer. Furthermore, due to their often flexible construction, transition ducts may crush, kink, or deform thereby reducing their effective cross sectional area. This can lead to excessive backpressure, restricted venting, and lint leakage in the dryer and exhaust system.

2.4.3 Exhaust Systems Convey Air and Discharge Lint

During normal operation, lint particles travel with the exhaust air stream. In the exhaust ducting, the lint particles will be captured—either intentionally on a lint screen or deposited unintentionally such as on a sharp edge, will leak out of the exhaust ducting, or will be passed through the system. Figure 7 below outlines the mass flow for clothes dryer lint from its origins during clothes dryer operation through the entire exhaust system. In each section of the system, lint may leak out, pass through, or be captured or deposited. The lint deposited within the clothes dryer cabinet will likely remain there and continue to accumulate until it is cleaned by an authorized service technician. However, lint that is leaked from the transition or permanent duct has the potential to accumulate outside the clothes dryer or be pulled back into the clothes dryer with make-up air, thus increasing the opportunity for accumulation within the clothes dryer cabinet. Deposited lint within the exhaust system can restrict or block airflow within the venting system.

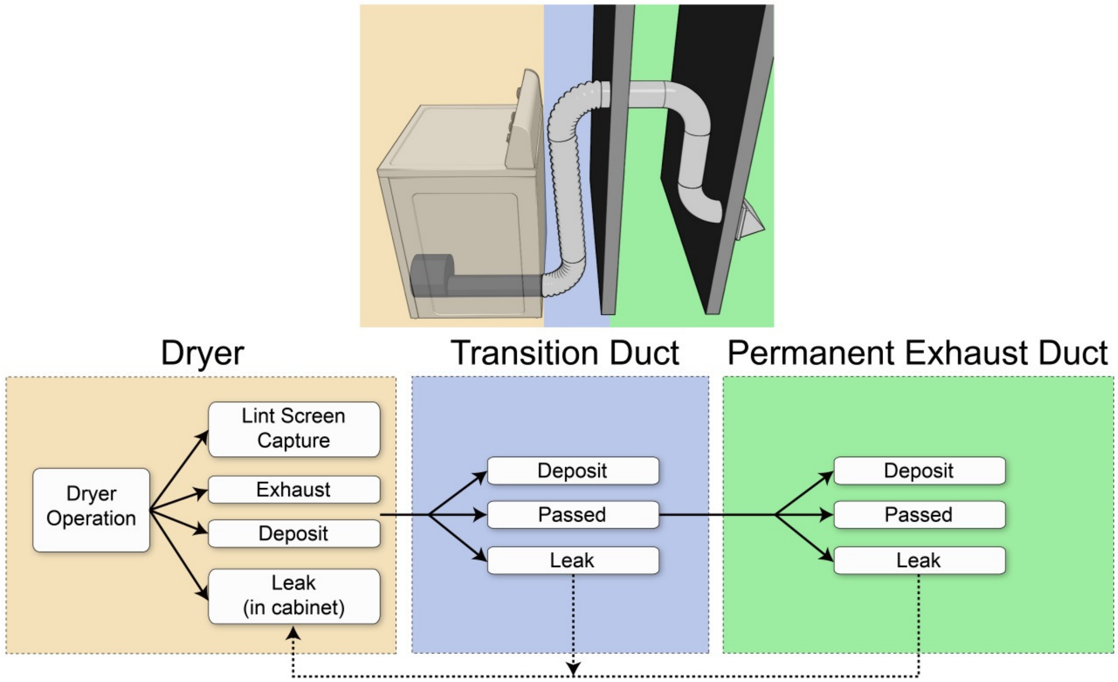

Figure 7. Mass flow material balance for clothes dryer lint.

A restriction in the exhaust system will ultimately limit the air flow rate through the dryer. For an electrically-heated dryer, the reduction in air flow can elevate the temperature of the electrical heating element. In the case of a gas-heated clothes dryer, the reduction in air flow, which is used for the combustion of the fuel gas, can result in abnormal burner performance leading to burn flame misdirection, lengthening, or flame roll-out of the combustion chamber. A consumer will experience a prolonged drying time as a result of poor exhaust.

Due to the effect of exhaust venting on both fire risk and overall dryer performance, all manufacturers provide guidance on acceptable dryer venting systems. Manufacturers include installation instructions and guidance for exhaust systems with each clothes dryer. Additional guidance can be found in local building codes and other safety codes such as the National Fuel Gas Code,[20] International Mechanical Code,[21] International Residential Code,[22] and the US Army Corps of Engineers ETL1110-3-483[23] specification. Other organizations associated with residential appliance safety, such as the NFPA,[24] CPSC,[25] and UL,[26] have also published fact sheets, warnings, and articles on the importance of proper venting and cleaning.[27]

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[20] National Fuel Gas Code, NFPA 54, ANSI Z223.1-1999, 1999 Edition.

[21] International Mechanical Code, 2000, Section 504.6.

[22] International Residential Code, 2000, Section M1501.

[23] Engineering and Design: Clothes Dryer Exhaust Venting, ETL1110-3-483, U.S. Army Corps of Engineers, March 23, 1998.

[24] "Clothes Dryers and Washing Machines Fact Sheet," NFPA, based on "Home Fires Involving Clothes Dryers and Washing Machines," NFPA USS57, 2012.

2.4.4 Electrolux Exhaust Requirements

An individual residence's exhaust ducting may span anywhere from a few feet to tens of feet through enclosed or concealed spaces in the home. Electrolux dryer installation manuals instruct consumers on exhaust system specifications to provide safe operation of its product. The instructions provide examples of prescriptive exhaust duct systems, e.g., type of ducting material, number of elbows, and exterior termination, and an alternative functional specification for systems that do not match the example systems. Figure 7 provides examples of the exhaust system installations for rigid and semi-rigid (flexible metal) ducting. For alternative installations, a functional specification of 0.75-inches of water column or less in backpressure at the dryer exhaust is required when run on the no-heat/air fluff cycle with no load. This pressure specification is based on historical testing performed by Electrolux and has been used in their instructions for several years.[28]

Number of 90° Turns	MAXIMUM LENGTH of 4" (10.2 cm) Dia. Rigid Metal Duct		
	VENT HOOD TYPE		
	(Preferred)		
	4" (10.2 cm)	Louvered	2½" (6.35 cm)
0	60 ft. (18.28 m)		48 ft.(14.63 m)
1	52 ft. (15.84 m)		40 ft.(12.19 m)
2	44 ft. (13.41 m)		32 ft. (9.75 m)
3	32 ft. (9.75 m)		24 ft. (7.31 m)
4	28 ft. (8.53 m)		16 ft. (4.87 m)

Number of 90° Turns	MAXIMUM LENGTH of 4" (10.2 cm) Dia. Flexible Metal Duct		
	VENT HOOD TYPE		
	(Preferred)		
	4" (10.2 cm)	Louvered	2½" (6.35 cm)
0	30 ft. (9.14 m)		18 ft. (5.49 m)
1	22 ft. (6.71 m)		14 ft. (4.27 m)
2	14 ft. (4.27 m)		10 ft. (3.05 m)
3	NOT RECOMMENDED		

P/N 134296400B (0404)

Figure 8. Exhaust duct installation tables from an example installation manual.

Permanent exhaust ducts installed in homes may exhibit various routing and configuration layouts. As the length, number of turns, nature of ducting, and maintenance vary from individual home to individual home, the ability of the permanent exhaust duct to allow adequate air flow for the clothes dryer will be affected. Likewise, replacing one dryer with another will lead to differing exhaust performance due to differences such as fan capacity, controls, leakage, and other design, assembly, or wear differences. Consideration of the individual exhaust system

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[25] "Overheated Clothes Dryers Can Cause Fires," CPSC Safety Alert, Publication 5022 062003 022012.

[26] "Product Safety Tips, Clothes Dryers," UL, http://www.ul.com/global/por/pages/offerings/perspectives/consumer/productsafety/dryers/

[27] "Help prevent common household fires," Travelers Insurance, https://www.travelers.com/prepare-prevent/home/fire-safety/house-fires.aspx, "Truths and myths of dryer fires," Consumer Reports, http://www.consumerreports.org/cro/2012/08/truths-and-myths-of-dryer-fires/index.htm, "10 Easy Ways to Make Your Home Safer," State Farm, http://learningcenter.statefarm.com/residence/safety-1/10-easy-ways-to-make-your-home-safer/, "Clean Your Dryer Vent," Allstate, http://www.allstate.com/tools-and-resources/home-insurance/clean-dryer-vent.aspx.

[28] Deposition of Brian Ripley, March 14, 2013, pages 154-156.

should be provided in each incident to understand the exhaust system's effects on dryer performance and role in the cause of the fire.

The Plaintiffs have claimed that Electrolux-manufactured clothes dryers will collect lint behind the drum in a manner that unreasonably increases the fire risk posed by the appliance; however, they have done nothing to demonstrate that excessive lint accumulations noted in some clothes dryers are not due to improper installation of exhaust ducting. Improper venting and lack of cleaning by an authorized servicer may lead to potentially hazardous accumulations of lint inside an individual dryer cabinet during the life of the product.

3 Clothes Dryer Fires

Clothes dryers are a unique type of major consumer appliance from a fire safety standpoint because they contain both a competent ignition source and a readily-ignited fuel (i.e., garments and lint) during normal operation. Given the large population and nature of the appliance, many annual fire incidents are reported. These fire incidents involve clothes dryers produced by all manufacturers and have been attributed to a variety of causes. Each fire incident is unique with specific facts and background.

In this section of the report, I will discuss the scientific methodology for investigating fires including those involving clothes dryers and provide an overview of common potential clothes dryer fire causes. Lint is one of the primary fuels that may be involved in a clothes dryer fire and is the source of the Plaintiffs' allegations in this matter. Thus, I will provide an overview of the role of lint in clothes dryer fires, lint in Electrolux-manufactured clothes dryers, and the Plaintiffs' lint accumulation and ignition allegations. Specifically, I will discuss lint-related fires and the pertinence of the produced Electrolux tests, Plaintiffs' tests, and my experiences. I will also explain the differences in lint accumulation and potential fire causes between gas-heated and electrically-heated dryers that the Plaintiffs have disregarded.

Finally, I will analyze the Plaintiffs' fire cause hypothesis and its logical progression based upon scientific principles and the produced testing. I will demonstrate that the Plaintiffs' consultants have employed expectation and confirmation bias in concluding that Plaintiffs' defect theory accurately states the cause of each fire while ignoring the physical evidence and witness observations that indicate otherwise.

Each fire incident involving a clothes dryer is a product of the specific appliance, installation, use and maintenance history, and other incident-specific factors. In this section I will outline potential dryer fire causes, the conclusions from fire tests involving clothes dryers, and the discrepancies between the Plaintiffs' fire cause and progression hypothesis and scientific fire dynamics principles.

3.1 Scientific Fire Investigation

A proper fire investigation applies knowledge of fire dynamics, factual data, witness observations, and other physical evidence to identify an area of fire origin. Plausible ignition sources are then identified within the area of origin for further scientific analysis. NFPA 921 is a useful guide for fire investigations. NFPA 921 details the basic methodology for conducting an objective and systematic investigation with attention to all relevant details. Fires can be destructive events that damage and destroy the evidence that is necessary to directly prove the sequence of ignition and stages of fire growth. Thus, scientific principles must be employed to objectively investigate and understand the most likely causes of ignition and stages of fire growth.

Specifically, NFPA 921 endorses use of the scientific method of inquiry for fire investigation. This pertains not only to the determination of the fire's origin at the scene, but also to analysis

of potential causes. As stated in NFPA 921, "The scientific method is a principle of inquiry that forms a basis for legitimate scientific and engineering processes, including fire incident investigation.[29]" The scientific method is an iterative process consisting of the following general steps:

- Collect the data
- Analyze the data
- Develop hypotheses
- Test hypotheses

This process should be conducted iteratively until "all feasible hypotheses have been tested and one is determined to be **uniquely consistent** with the facts, and with the principles of science."[30] The scientific method should be applied to determine the fire's origin and to identify and eliminate plausible fire causes.

Three components are necessary for a fire to occur inside a clothes dryer: fuel, air, and a competent ignition source. These are necessary components but their presence alone is not sufficient to lead to a fire. The competent ignition source must interact with a sufficient quantity of fuel under the right conditions to cause it to ignite. That initial fuel must continue to burn long enough or intensely enough to ignite other fuels, thus leading to fire spread within the clothes dryer. The physically realizable sequence of events that describe fire initiation and growth is called a fire scenario.

3.1.1 Structuring the Cause Analysis

There are several objective and systematic analytical tools that can be applied to develop and evaluate hypothetical fire scenarios (e.g., fault tree analysis, cause and effect diagram, etc.). All rely upon sound logic and reasoning, scientific principles, and facts. Although these techniques do not have to be applied directly in each investigation, every fire scenario should be describable by one of these methods, thus it will be consistent with the principles of science and facts of the case.

Whichever technique is chosen, the goal should be to disprove each hypothesis until only those which are uniquely consistent with the facts remains.[31] All available facts regarding the post-fire state of the dryer, the witness observations of the fire, the use and maintenance history of the dryer, the installation of the dryer, and the environment in which it was operation should be considered and compared to the cause hypotheses.

Determining the cause of a fire is not completed by simply identifying a first fuel of ignition and a competent ignition source. The cause includes the "circumstances, conditions, or agencies"

[29] NFPA 921 Guide for Fire and Explosion Investigations, 2011 edition, page 17.

[30] **Emphasis added**, NFPA 921 Guide for Fire and Explosion Investigations, 2011 edition, page 18.

[31] "**18.6.4 Means of Hypothesis Testing**. When testing a hypothesis, the investigator should attempt to disprove, rather than to confirm, the hypothesis. If the hypothesis cannot be disproved, then it may be accepted as either possible or probable." NFPA 921, 2011.

that allow for the fuel, air, and ignition source to interact and start a fire.[32] The installation, use, and maintenance history of the dryer should be considered when determining a cause for a fire involving a dryer.

3.1.2 Potential Causes for Clothes Dryer Fires

To adequately assess the potential fire causes in a given clothes dryer unit, the facts surrounding the fire incident must be known and understood. The scientific analyst must understand the operation and failure modes of the clothes dryer including controls, physical processes, mechanical and electrical components, fire dynamics of convection systems, gas-heated appliances, electrical failure modes, ignition criteria, flame spread, and the combustion behavior of textiles and plastics. Each appliance and each incident should be treated as a unique event and investigated without pre-supposition of the cause of the fire. If a specific clothes dryer has been concluded to be the origin of the fire, there are several classes of potentially fire-causing failure modes to be considered depending upon the circumstances, evidence, and witness observations. I use the term "failure mode" here synonymously with fire cause in order to generically describe the circumstances leading to ignition of the first fuel.

General types of failure modes can be grouped according to mechanical failures, electrical equipment failures, self-heating (e.g., spontaneous combustion), and gas-heating system-related scenarios. In clothes dryers, failure modes are typically related to these sub-systems and may not necessarily be tracked back to a single component source. The primary fuels in clothes dryers are combustible lint, combustible garments, combustible plastics, and fuel gas for gas-heated dryers. The most likely ignition source within all clothes dryers for lint or garments is the energized heating element or firing burner. Combustible plastic components are most likely to be ignited by pre-existing fires involving lint, garments, and fuel gas. The facts surrounding an individual dryer and its installation may indicate additional or different potential fire causes for consideration.

3.2 Lint-Related Fires in Clothes Dryers

As mentioned earlier, lint is the product of wear on garments in the laundering process. Lint shed from garments is mostly composed of cotton fibers, but my experience indicates that other materials such as synthetic fibers, animal hair, dust, and fabric softener may be present in accumulated lint deposits. Clothes dryers always contain combustible lint and combustible garments at some point during a normal drying cycle. The most likely ignition source within all clothes dryers for lint or garments is the energized heating element or firing burner. All clothes dryers, regardless of manufacturer, have these same factors present. The clothes dryer industry, standards organizations, the CPSC, and other agencies all recognize that lint accumulation is likely inside the clothes dryer system for all types of clothes dryers; thus, they provide guidance for consumers to have the clothes dryer system cleaned periodically to reduce the potential fire

[32] "**18.6.5.2* Ignition Source vs Fire Cause**. The investigator should remember that the cause of a fire is defined as "the circumstances, conditions, or agencies that bring together a fuel, ignition source, and oxidizer (such as air or oxygen) resulting in a fire or a combustion explosion" (see the Definitions Chapter; Fire Cause). The identification of an ignition source and a first fuel is not sufficient to determine a cause." NFPA 921, 2011.

hazard.[33] These factors and a potential lint fire hazard are not features unique to Electrolux-manufactured or any other manufacturers' clothes dryer designs; all clothes dryers accumulate lint and can be involved in a fire.

For example, the U.S. Consumer Product Safety Commission (CPSC) commissioned a series of studies of clothes dryers in the late 1990s and early 2000s to attempt to identify and address the causes of fires in clothes dryers.[34] The 1999 CPSC study reviewed dryer population numbers and fire incident rates. The study concluded that lint-blocked exhaust ducts were a significant cause of overheating in clothes dryers during their life that could lead to internal electrical component failure and fires. The May 2003 CPSC study report showed lint can accumulate in dryers due to restricted venting as well as due to normal operation. This study did not test gas-heated pan-style dryers, and in fact, the lint distribution sub-study did not include a pan-style dryer and instead focused on a bulkhead-style dryer. Thus, from the CPSC report it is evident that lint accumulation within the dryer cabinet is not unique to Electrolux-manufactured dryers with heater pans.

Lint is a potential fuel in a clothes dryer fire. However, finding lint in a clothes dryer that has participated in a fire incident does not confirm that lint was the first item ignited or even a participatory fuel in the fire. The appearance of a post-fire lint deposit is dependent upon its density, location, and the extent of the overall fire. Lint is primarily composed of cotton cellulose fibers, which are a natural polymer. Cellulose fibers are well studied in the scientific literature (e.g., thermal analysis, textile fabrics, and fire dynamics) for both cotton and wood derived materials, and I have conducted self-heating, oven heating, and ignition tests of these types of materials throughout my career and Ph.D. research. Cellulose undergoes chemical and physical changes upon heating. Cotton fibers, which may start as white (without added dye or contaminants) in color, will transform from a yellow to brown to black color depending upon the temperature, mode of heat transfer, rate of heat transfer, and airflow conditions. Cotton fibers char and ablate under high rates of heating without ignition. Under high enough rates of heating, cotton fibers will ignite under a smoldering combustion regime. If the convection conditions and sample mass are appropriate for the rate of heat flux into the fibers, then smoldering may transition to flaming or flaming may be directly initiated.

Lint deposits have a fluffy, fuzzy surface. Heating of lint deposits without ignition will cause the deposits to shrink and ablate. In my experience, non-fire involved lint deposits retain the characteristically fluffy and fuzzy appearance but may be shrunken and discolored to a brown or black color. Some consultants have referred to black-colored lint as "charred lint;" however, this charred appearance is not necessarily a consequence of flaming or smoldering combustion of the lint.

Based on my experience, if a fluffy lint deposit is ignited in a low-air velocity situation, such as horizontal deposits in the cabinet base, the lint deposit will quickly spread flames across the

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[33] For example, "Clothes Dryer Fact Sheet." Association of Home Appliance Manufacturers. "Clothes Dryer Fires in Residential Buildings." USFA Topical Fire Research Series, 7(1), 2007. ANSI Z21.5.1-2002, Section 1.22.8. "Home Fires Involving Clothes Dryers and Washing Machines," NFPA USS57, 2009.

[34] Memorandum and Report on Electric and Gas Clothes Dryers Staff Evaluation and Contractor Report, February 25, 2000; CPSC Final Report on Electric Clothes Dryers and Lint Ignition Characteristics, May 2003.

surface then be reduced to random slowly burning islands of lint. Depending upon the external fire and the density of the deposits, the lint deposits may be completely consumed or underlying non-burned lint may survive with a burned top layer. In high convection regions such as the heater pan or an air duct in an operating dryer, flaming ignition of a lint deposit will lead to consumption of even dense deposits. The forced convection flaming combustion process will erode the surface of the lint deposit leaving a non-fuzzy appearance. Fire suppression efforts involving a dryer can also easily displace lint and thermally degraded lint residue masking the pre-fire presence of lint accumulations.

Lint that the Wright Group has hypothesized as the first item ignited in the alleged lint defect fire scenario is at best only one of many potential fuels inside a clothes dryer. The pre-fire presence of lint deposits is also a necessary condition for this hypothesized fire scenario.

In their reports, the Wright Group has claimed that the examples of lint accumulation in heater pans from their past examinations were evidence that lint that accumulates behind the rear of the drum can be easily ignited by the heat source. However, these lint deposits that they have documented largely don't show any evidence of participating in a fire. They are apparently fixed in the same location as before the fire, and they are not consumed. The deposits may be discolored and sometimes shrunken, but this appearance is completely consistent with exposure to hot combustion products from a fire inside a clothes dryer that did not involve this lint.

3.2.1 Electrolux Tests, Experience, and Analysis of Lint and Fires

There are some examples of well-controlled and thoroughly-documented lint accumulation tests for Electrolux-manufactured clothes dryers. Electrolux continually conducted accelerated life reliability testing on their clothes dryers, which served as a portion of their technical basis for evaluating lint deposition within the succeeding model generations. These accelerated life tests used hundreds of drying cycles to approximate lifetime reliability of mechanical components in the clothes dryers. I have reviewed the materials provided in the Engineering Design Binders for the Alliance Dryer Project from the mid-1990s,[35] the GE Dryer Project from the late 1990s,[36] and other discovery materials. None of that work demonstrated that lint could accumulate in the heater pan and ignite in a fashion consistent with the Plaintiffs' uniform lint defect and fire scenario allegations.

I conducted a study of 10 Electrolux electrically-heated clothes dryers that had been operated identically for several months in the Electrolux accelerated life testing laboratory.[37] No significant amounts of lint accumulated near the heating element in the pan in these clothes dryers. (Figure 9 is a photograph of the thermally-degraded lint deposits in the heater pan from a 2002 manufactured electrically-heated clothes dryer.) None of these units had significant lint accumulations in the space between the baffle ring and the back of the drum either. Lint did accumulate to a varied extent within the cabinet and within the plastic air duct, but this lint was not near likely potential ignition sources. Electrolux also provided a photograph of a gas-heated

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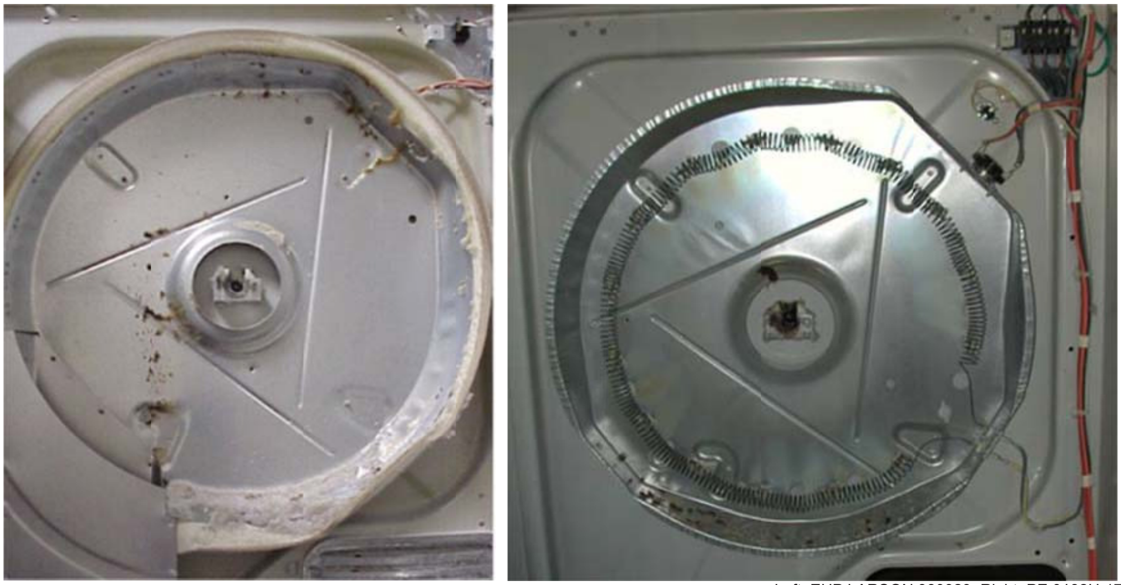
[35] EHP_LARSON112789-118834, EHP_LARSON236494-237342

[36] EHP_LARSON262772-263190, EHP_LARSON365480-365481

[37] Morrison DR, Ogle RA, MacDonald M. Analyzing lint deposition within the residential electric clothes dryer. 2004 International Appliance Technical Conference, March 2004.

dryer (left in Figure 9) that had been operated for 5000 cycles in the 2004-2005 Japanese claims investigations file. This heater pan shows a small lint deposit at the 6 o'clock position, which is not thermally degraded.



Left: EHP LARSON 380929; Right: PE 0182H-17

Figure 9. Example of lint accumulation in the heater pan for: (left) a gas-heated dryer operated for 5000 cycles with the maximum recommended backpressure (circa March 2005) and (right) an electrically-heated dryer (Model FER211AS1, Serial No. XD22107877, 73 continuous days/3.48 years of operation with a load, 146 days/7.3 years of operation without a load.

Plaintiffs' consultants have criticized Electrolux for not further investigating the findings of accumulated lint in some clothes dryers. Electrolux deponents have stated several times in deposition testimony that excessive accumulation of lint in the heater pan for gas-heated dryers, electrically-heated dryers, and in the area between the baffle ring and the back of the drum is due to inadequate venting of the individual clothes dryer. The discovery documents contain several examples of test programs and investigations conducted to evaluate this very issue.

3.2.1.1 Alliance Platform Design Process

Based on my review of the discovery documents, Electrolux staff conducted several layers of testing and root cause analysis during the 1990s and 2000s to evaluate, investigate, and make design changes to limit lint accumulation inside clothes dryers. Documents from more than a decade ago no longer remain due to corporate document retention policies.[38] However, historical design binders containing project documents for the Alliance platform design as well as documents for the GE project were provided in the discovery documents. The Alliance platform was developed in the mid-1990s and serves as the basis for the ball-hitch units

[38] Deposition of Carl King, September 6, 2013, pages 113-114; King Deposition Exhibits 162 and 168.

manufactured from 2000 through 2011. This platform was the result of several iterations of testing and analysis by Electrolux engineers.[39]

The Alliance platform dryer design objectives were set on February 28, 1994, which included better air flow than the previous dryer, a better energy efficiency rating, lower cabinet temperatures, and a lower service call rate.[40] Production began two years later, on April 15, 1996.[41] In the interim development stage, several iterations of dryers were tested and analyzed by Electrolux engineers.[42] This development included accelerated lifetime testing to represent 10 years of operation with regular inspection of the cabinet. Testing also focused on issues related to lint accumulation in the cabinet.[43]

An objective of the testing was to eliminate lint leakage and excessive accumulation within the dryer. Smoke migration was tested at 100% blockage to determine potential leak points.[44] A subsequent test report indicated that lint leakage was observed escaping from the internal exhaust tube, connection to the blower, and blower housing when the dryer was operated at 1.00-inches of water column back pressure. [45]

When an unacceptable amount of lint accumulation was later discovered in some of the blower wheels during consumer usage testing, production was postponed to investigate the issue.[46] The level of lint accumulation at the blower wheel was identified as a "SHOW STOPPER" until the problem was solved.[47]

Testing continued, and external engineering firms were contacted to help with the problem.[48] It appeared that a problem existed in the temporary tooling used to produce the blower housing.[49] Testing with permanent tooling for the blower housing mold showed improvement.[50] After some more investigation to confirm that the problem wheels were produced with the temporary tooling, the blower wheels were no longer considered an issue for production.[51]

Leaks were discovered at the connection between the exhaust tube and the blower housing.[52] The aluminum tape sealing the connection between the exhaust tube and the blower housing

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39 Engineering design binders [EHP LARSON 112789-118834; 236494-237342]

40 Alliance Dryer Design Objectives, signed February 28, 1994, EHP LARSON 112931.

41 Enhanced Dryer – Production Preparation Meeting, April 12, 1996, EHP LARSON 117117-117124.

42 Alliance engineering design binders, EHP LARSON 112789-118834; EHP LARSON 236494-237342.

43 Lint Travel of Alliance Dryer, 12/6/95, EHP LARSON 118519.

44 EHP LARSON 114358, November 29, 1995; EHP LARSON 118515, December 7, 1995.

45 EHP LARSON 114359, January 11, 1996.

46 EHP LARSON 114164, December 5, 1995; EHP LARSON 116111, February 26, 1996.

47 EHP LARSON 116129, March 5, 1996.

48 EHP LARSON 113450-113536

49 EHP LARSON 116028, January 12, 1996.

50 EHP LARSON 114540, March 8, 1996.

51 EHP LARSON 116149, March 15, 1996,

52 EHP LARSON 114358, November 29, 1995; EHP LARSON 114356, February 13, 1996.

was capable of coming loose in conditions of high humidity.[53] It was decided to set a goal of replacing the tape with a rubber gasket.[54] Around the same time, testing specific to the foam gasket resulted in a recommendation to make the gasket thinner to improve airflow.[55] Lint was found adhered to the outside of the gasket, implying that air was being drawn through the foam into the blower and reducing the draw through the drum.

Maytag and Whirlpool units were tested and found to have "the same kind of difficulties with the lint accumulation issue on the base."[56] The aluminum tape was switched to a more resilient type.[57] However, a better solution was pursued. A rubber gasket was designed in September of 1996.[58] A design performance verification was initiated and an FMECA was performed in November of 1996.[59] The FMECA worksheet is provided in Figure 10, and indicates that Electrolux engineers defined a fire as a Severity (SV) value of 10, Occurrence (OC) value of 4, and Detectability (DT) value of 2 for an RPN of 80 for an internal fire. The gasket was developed and passed initial testing in February of 1997.[60] After almost a year and a half of effort, the design performance verification was successfully completed and the rubber gasket was released for production.[61] The product improvements made throughout the Alliance project were applied to all of Electrolux's production dryers.[62]

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[53] EHP LARSON 114341, February 5, 1996.

[54] EHP LARSON 116149, March 15, 1996,

[55] EHP LARSON 114232, February 6, 1996.

[56] EHP LARSON 116153, April 2, 1996.

[57] EHP LARSON 115140, April 9, 1996.

[58] EHP LARSON 114462, September 4, 1996.

[59] EHP LARSON 114466, November 11, 1996; EHP LARSON 114464, November 21, 1996; EHP LARSON 114461, November 24, 1996.

[60] EHP LARSON 114467, February 25, 1997.

[61] EHP LARSON 114457, August 4, 1997.

[62] EHP LARSON 113185, initiated January 11, 1995, final approval June 19, 1995.

Project Title: New Exhaust Tube Seal	Products Affected: 27" F/S Dryers	Part Source: Cupples Rubber Company	Serial Number:
Project Number: 94-0090		Forecast Production Date: 3/1/96	FMECA Date (Orig):
Part Name: Exhaust Tube Seal	Team Members:	Subsystems Affected: Motor/Blower Assembly	FMECA Date (Rev):
Part Number: 1316333		FMECAs Referenced:	Next Review Date:

Part Function	Potential Failure Mode	Potential Failure Effect(s)	SV	•	Potential Failure Cause(s)	OC	Design Verification(s)	DT	RPN	Recommended Action(s): Test Evaluation Number	Responsibility and Completion Date(s)	Action Results			
												SV	OC	DT	RPN
Seal joint between blower housing and exhaust tube.	Cannot assemble	Scrap	5		Not dimensionally correct	2	Capability run / QSIR	2				5	4	2	40
		Downtime	5		Incorrect design	2	Pilots	2							
					Incorrect assembly procedure	4									
	Does not seal	Lint leak in cabinet	8		Not dimensionally correct	2	Capability run / QSIR	6				10	4	2	80
		Fire	10		Incorrect design	2	Lint abuse test	2							
		Lint in motor	7		Incorrect installation	4	Reliability test	2							
		Service call	9				Transit test	8							
	Deteriorates over time (Gas Dryers)	Lint leak	8		Incorrect design	2	Reliability test	2				10	2	2	40
		Fire	10		Incorrect material	2	Lint abuse test	4							
		Lint in motor	7												
		Service call	8												

Develop spec on length + tension of band seal around 4"Ø O.D. tube.

EHP LARSON 114465

Figure 10. FMECA for New Exhaust Tube Seal dated November 21, 1996.

3.2.1.2 Japanese Dryer Investigation in 2004-2005

In the mid-2000s, Electrolux was notified of a product safety concern with White Westinghouse Frigidaire branded and GE branded Electrolux-manufactured dryers in Japan.[63,64] Electrolux initiated a detailed investigation and root cause analysis of the known Japanese fire incidents. Seven fires were reported within a population of 3536 dryers,[65] which was an obvious indication to Electrolux of a product safety concern. As a result, Electrolux investigated several individual incident clothes dryers, installation conditions for those dryers, as well as performed detailed dryer testing and a root cause analysis. In parallel to Electrolux's investigation, an investigation was also performed by the Japanese authorities. The issues under investigation in that matter were similar to the ongoing investigations and claims proposed by the Wright Group over the last several years.

The aforementioned dryer fire incidents were investigated by the Japanese authorities without a thorough understanding of the dynamics and factors affecting clothes dryer operations and fire scenarios. The claims made by the Japanese investigators were shown to be naïve and incorrect with respect to the actual dynamics governing clothes dryer function, lint accumulation, and lint fires. As a result of Electrolux's parallel root cause investigation and analysis, Electrolux presented an Ishikawa diagram (e.g. Figure 11) to the Japanese authorities refuting the claims of the Japanese investigators and demonstrating the contributing factors likely responsible for the fire incidents.

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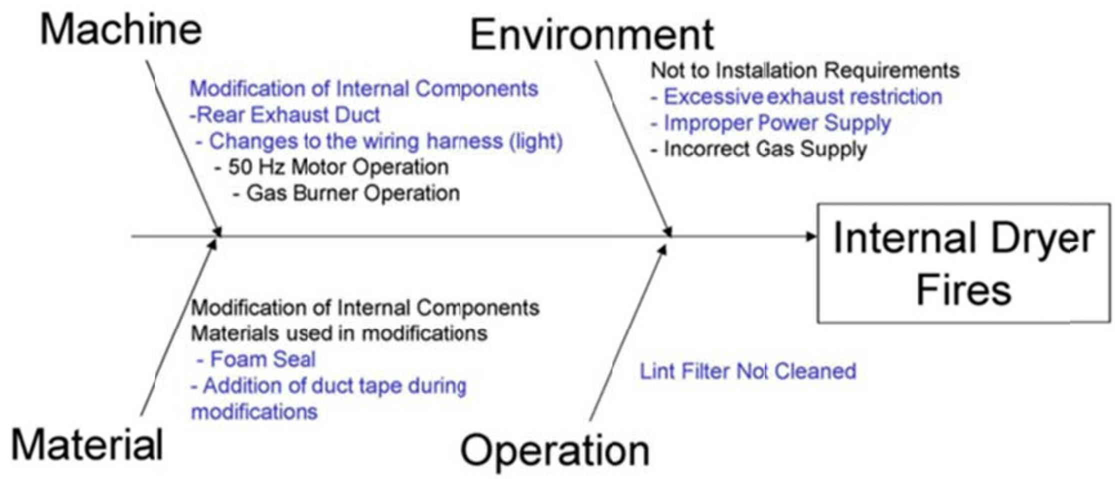
63 Announcement concerning Fire Accidents and Free inspection of White Westing House Gas Clothes Dryers, December 15, 2004, EHP LARSON 381033.

64 Dryer Analysis Update: EHP Gas Dryer – 3 wire, 120V single phase, 60 Hz AC, January 19, 2005, EHP LARSON 380713-380725.

65 Dryer Analysis Update: EHP Gas Dryer – 3 wire, 120V single phase, 60 Hz AC, January 19, 2005, EHP LARSON 380714.



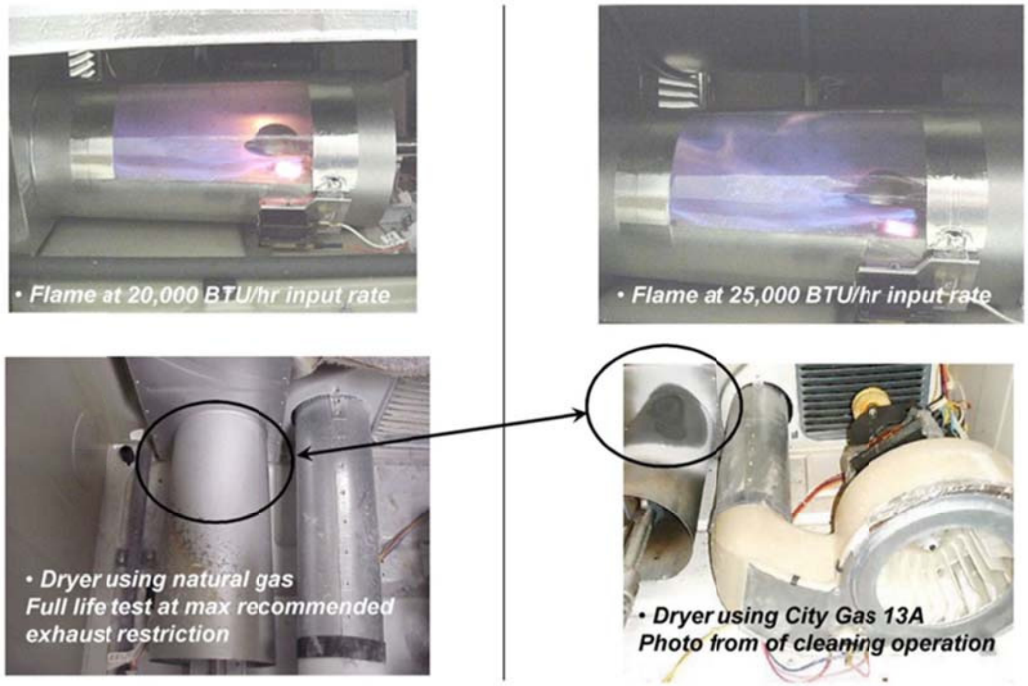
From EHP LARSON 380690

Figure 11. Example Ishikawa diagram created by Electrolux during root cause analysis of the Japanese clothes dryer fires circa 2005.

Electrolux engineers determined that the root causes for the dryer fires included the following installation and product modification issues:[66]

1. Modifications of the Dryer unknown to Electrolux
    a. Removal of the rigid metal exhaust tube and rubber seal, replaced by a flexible metal tube and plastic duct tape;
    b. Modification of the wiring harness with the addition of terminations to the two control thermostats and the addition of a light to the console; and
    c. The introduction of combustible materials inside the dryer cabinet.
2. Installation anomalies
    a. Japan's electrical supply of 100V at 50Hz and 60Hz is below the specified power supply of 120V at 60Hz, and that
    b. The documented large amounts of lint accumulation inside the dryer cabinet were most likely a result of excessive exhaust restriction.
    c. Improper gas supply: Japanese natural gas supply results in a 25% increase in burner heat output (BTU/hr) and larger flame compared to the US natural gas supply (see Figure 12).

[66] Response to JIA Report, January 6, 2005, EHP LARSON 380951-380952.



From EHP LARSON 380843

Figure 12. Comparison of the effects of heat input from fuel gas. The burner system is rated for 20,000 BTU/hr (left). A higher heat input causes a larger flame that fills more of the combustion chamber.

As a result of this investigation, Electrolux identified several corrective actions for their Japanese distributor and Japanese authorities to eliminate these root causes. The recommended corrective actions for the Japanese gas-heated dryers were to inspect and clean field units, add a thermal fuse, replace the gas orifice in all products in Japan and to measure, and correct if required, the exhaust system restriction.[67,68,69] The change in the gas orifice served to reduce the fuel gas flow rate thereby correcting for the gas supply differences (heating value) between United States and Japan. This is analogous to converting an appliance from natural gas to propane which was briefly discussed in Section 2.1.2.

The lint deposition patterns documented in the Japanese dryers are similar to the lint deposition patterns that I have seen in U.S. Electrolux gas-heated clothes dryers with restricted exhausts. I do not know if electrically-heated dryers were also imported to Japan, or if they suffered from similar installation and modification concerns. However, lint deposits as well as the potential for the heating system as an ignition source are markedly different between gas-heated and electrically-heated dryers.

67 Dryer Analysis Update, May 24, 2005, EHP LARSON 380726-380748.

68 Dryer Analysis Update, September 13, 2005, EHP LARSON 380832-380848.

69 Deposition of Brian Ripley, July 24, 2013, pages 137-139.

The recommended corrective actions addressed the specific failure modes documented in the Japanese fire incidents. Although all of the Japanese dryers at issue were gas-heated appliances and no mention was made of electrically-heated dryers within the documents, the extensive and detailed documentation of the Japanese Dryer investigation and root cause analysis demonstrated Electrolux's internal understanding and experience regarding clothes dryer safety, product support, and root cause failure analysis.

3.2.2 Differences between Lint Deposition in Gas and Electric Dryers

The Wright Group claimed that there was no significant difference between gas-heated and electrically-heated clothes dryers in relation to the alleged uniform lint design defect:

> *Though there are differences in the mechanisms by which the lint collects in the area behind the drum between the gas and electric designs, both allow for collection of lint in close proximity to the heat source which provides a higher probability of a lint fire occurring than alternative designs used in the industry.*[70]

On the contrary, based on my past examinations of used Electrolux clothes dryers, testing, and review of discovery documents, if excessive amounts of lint accumulate in the heater pan, then certain lint deposition patterns are apparent, and the accumulation patterns differ significantly between gas-heated and electrically-heated dryers. These deposition patterns are consistent with the different configurations, basic engineering principles, and the airflow (see Figure 3) through the gas-heated and electrically-heated heater pans. The degree of lint accumulation in the heater pan and baffle is variable, and based on the historical testing reported in the discovery documents along with my experience, it will be greater for older, poorly vented clothes dryers than newer, properly vented dryers. The Wright Group has documented numerous examples of lint accumulation in heater pans on their supplied hard drive; however, the exhaust ducting installations, use histories, and maintenance histories for these appliances were not documented. Interpretation of the significance of lint deposition patterns in these clothes dryers must be cautiously conducted for the following reasons:

1. The usage history, exhaust installation, and maintenance history are not provided.
2. Fire incidents involving an individual dryer may affect lint deposits by burning them, by thermal degradation, or through fire suppression efforts.
3. Evidence handling and transportation effects such as bouncing, excess vibrations, and other physical movements may displace previously stationary lint deposits.
4. Disassembly, examination, and reassembly may all affect the location and consistency of previously stationary lint deposits.

The documented patterns of lint deposition are consistent in their orientation and location for those dryers where lint has accumulated. But, these deposition patterns are not similar between gas-heated and electrically-heated clothes dryers because, as discussed above in Section 2.1, the airflow patterns through the two types of heating systems are very different. Lint is a particulate solid and will be transported due to convection (i.e., carried by air streams) within the clothes dryer cabinet and air system. The configuration and airflow patterns are significantly different

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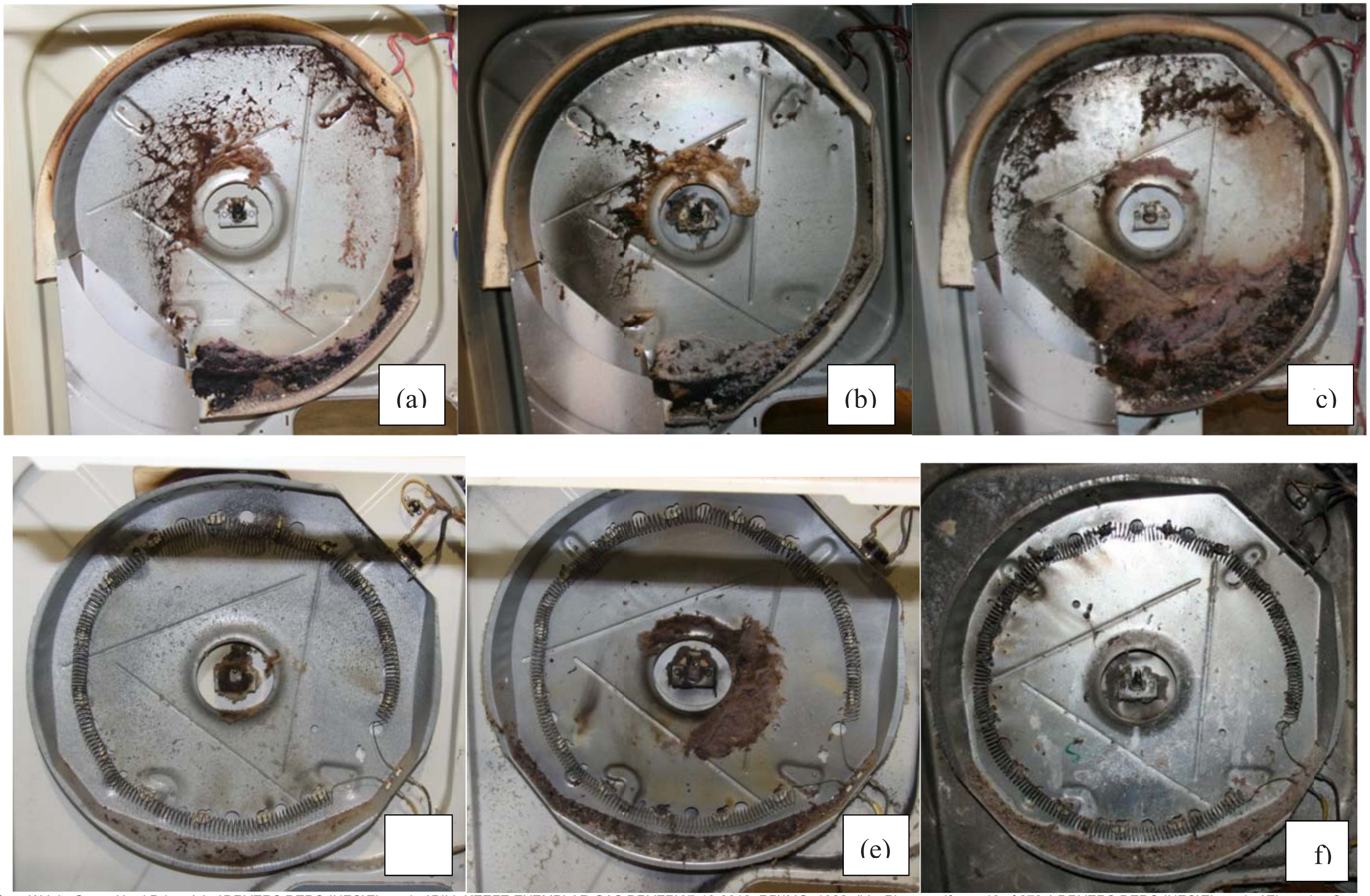
[70] E.g., Wright Group report (Blake), dated December 20, 2013, page 45.

between the two types of heater pans. Figure 13 depicts six examples of lint accumulation in heater pans that I retrieved from the hard drive provided by the Wright Group. I selected these images because it was apparent that the lint deposits were not degraded by a fire inside the clothes dryer cabinet or drum. Thus, these images support the difference in dynamics of lint accumulation, when it occurs, in the heater pans of the two types of dryers.

Representative gas heater pans (the top three images a-c in Figure 13) demonstrate lint deposits on the vertical back wall and outer circumference of the heater pan. Although I have not found any comprehensive studies that clearly detail the physical processes involved, I can infer based on my education and experience what physical processes are dominant in this system. These deposit patterns are indicative of particulates traveling into the heater pan with the incoming air through the combustion chamber. If the burner is firing, incoming airborne lint particulates will be vaporized without flaming. Deposits do not accumulate on the left side of the pan where the high temperature incoming air stream is too hot to allow the deposits to exist. The adhesion of lint to the back wall of the heater pan is likely due to high moisture levels in the incoming air when the burner is not firing that would be caused by inadequate ventilation of the dryer. Growth of lint deposits will be enhanced by high moisture levels in the air stream and lint-lint particle cohesive forces. The lint deposits collected in the bottom of the heater pan are due to particle impaction and settling against the bottom wall of the heater pan. The airflow has to also turn to move axially through the back wall of the drum, which can allow particle settling in the bottom of the heater pan to occur if the overall airflow velocity is too low to carry all of the particles into the drum.

Representative electric heater pans (the bottom three images d-f) demonstrate lint deposits that are significantly different from those in the gas heater pans (the top three images a-c). From my review of the Wright Group hard drive and experience in evaluating other Electrolux-manufactured clothes dryer fire incidents, the depicted types of deposits are representative of the type of lint accumulation possible in the electric heater pan. The lint deposits observed in heater pans d and f are very similar to the deposits I observed in my review of 10 accelerated life tested electrically-heated Electrolux dryers.[71] The airflow into the electric heater pan is much different since it enters radially around the perimeter of the heater pan and axially through holes in the back wall of the heater pan. Where airflow into the gas heater pan is tangential to the heater pan, centrifugal forces have an effect on lint deposition. In contrast, the radial and axial flow through the electric heater pan is not as likely to allow lint deposits to accumulate in the heater pan.

[71] Morrison DR, Ogle RA, MacDonald M. Analyzing lint deposition within the residential electric clothes dryer. 2004 International Appliance Technical Conference, March 2004.



Images from Wright Group Hard Drive: (a) - \DRYERS DEPO INFO\Electrolux\BILL KEEFE EXEMPLAR GAS DRYER\07-18-2012_RP\IMG_1022; (b) - Photos.pdf, pg. 46 of 278, \ DRYERS DEPO INFO\Electrolux\Electrolux Case Studies\Lint Accumulation\Heat Diffuser; (c) - Photos.pdf, pg. 61 of 278, \ DRYERS DEPO INFO\Electrolux\Electrolux Case Studies\Lint Accumulation\Heat Diffuser; (d) - \DRYERS DEPO INFO\Electrolux\Dryers\Electrolux Dryers_Electric\Freestanding Electric\EXEMPLAR_0045_FRIGIDAIRE_FDE436RES1_XD92490787_FII\100CANON\IMG_0132; (e) - \DRYERS DEPO INFO\Electrolux\Dryers\Electrolux Dryers_Electric\Freestanding Electric\EXEMPLAR_0042_GE_DVL223EB1WW_AD74633W_AMB\IMG_0215; (f) - Photos.pdf, pg. 67 of 278, \DRYERS DEPO INFO\Electrolux\Electrolux Case Studies\Lint Accumulation\Heat

Figure 13. Examples from Wright Group drive of lint accumulation in heater pans for gas-heated and electrically-heated dryers.

I have also observed that some, not all, dryers with lint accumulation in their heater pan have lint accumulated in the area between the baffle and the back wall of the drum. This lint is readily visible from the drum opening when looking at the rear wall of the drum. Figure 14 depicts two examples of lint deposits in this area. In contrast, I found no significant lint accumulation in this area when I studied the lint deposition in 10 clothes dryers that were tested in a controlled setting.[72] From examination of the deposits in several clothes dryers, I found that this type of deposit is sandwiched between the rear wall of the drum and the baffle ring. As a consequence when the baffle is removed, the restraint provided by the drum and baffle ring is removed and lint deposits are pulled from the drum wall. Previously adhered and stationary lint deposits can then appear to be loose within the baffle.

Images from Wright Group Hard Drive: Photos.pdf, pg. 217 of 383, \DRYERS DEPO INFO\Electrolux\Electrolux Case Studies\Lint Accumulation\58346_3-9-2011_MS; photos.pdf, pg. 145 of 154, \DRYERS DEPO INFO\Electrolux\Electrolux Case Studies\Lint Accumulation\Rear of Drum & Deflector

Figure 14. Examples of lint deposits in baffle rings.

3.2.3 Plaintiffs' Consultants' Lint Accumulation Tests

There are several examples of tests and individual analyses presented in the discovery documents and in the file materials provided by the Wright Group. The Wright Group has been involved in numerous litigation-related claims investigations; thus, they have created a large database of defense and plaintiff testing examples, reports, and testimony. However, other than dismissing the required maintenance for clothes dryers, the Wright Group have not provided any field examples of excessive lint accumulation inside a clothes dryer to compare against Electrolux's specified 18-month cleaning. I have reviewed the Wright Group hard drive contents several times in past matters, and I have found that they seem to rely most heavily on a select set of their tests to support the alleged reverse flow of lint from the drum back into the heater pan of Electrolux clothes dryers.

The Plaintiffs have relied upon several tests performed in the past by the Wright Group and some more recent testing to support their allegation of a uniform lint design defect. This design

[72] Morrison DR, Ogle RA, MacDonald M. Analyzing lint deposition within the residential electric clothes dryer. 2004 International Appliance Technical Conference, March 2004.

defect allegation has two primary parts: (1) lint excessively accumulates in the heater pan or baffle behind the drum, and (2) that lint is ignited causing a fire inside the dryer. First, in this section, I will discuss some of the Wright Group's more prevalent tests. I will demonstrate how these tests are not representative of the population of Electrolux dryers as they have alleged. Then in a subsequent section, I will discuss the fire dynamics aspects of other tests conducted by the Wright Group and how those impact the development and evaluation of fire cause hypotheses in Electrolux clothes dryers.

3.2.3.1 The 10 Towel Tests

The Wright Group relies primarily on its 10-towel tests from 2011 and 2012 to support its reverse lint flow hypothesis, which is the central part of the design defect allegation. The objective of these tests was to repeatedly dry a load of cotton bath towels in order to demonstrate the accumulation of lint in the heater pans of gas-heated dryers. The models of clothes dryers they used did not have a baffle attached to the backside of the drum. I did not witness these tests, and the documentation is limited to written test protocols, data summaries, and photographs. In the past, I have also reviewed deposition testimony of Mr. Ronald Parsons, of the Wright Group, who oversaw these tests. These tests do indicate that some lint accumulated in the heater pan during the course of the tests; however, I have significant doubts about the allegedly representative nature of the testing.

First, the documentation appears to indicate that a set of 40 new, unused cotton towels were used in the testing. It appears that each set of 10 towels was washed and dried for 5 laundering cycles with one load washing while the other dries and vice versa; thus, the towels were essentially new throughout the tests. From my experience, new cotton towels will generate a large quantity of lint, and the lint generation per load will drop significantly after the towels are laundered a few times. This observation was also demonstrated in the measurements of lint collected from the lint screen. I would characterize the lint loading as an aggressive and accelerated rate test compared to normal operating conditions. In comparison, standardized tests use a conditioned and often a mixed cotton (i.e., type of garment, fabric composition, etc.) load.[73] The 10 cotton towels created a 12-pound load, which generated a high rate of lint, and would also serve to restrict ventilation above the nominal 0.75-inch water column backpressure by blocking airflow through the drum and quickly blocking the lint screen. These tests were not representative of anticipated use and should be considered to be forced-failure type tests.

The test involving the used 2000 Frigidaire Model FDG648GHS0 (S/N XD01904902) demonstrated the most dramatic lint accumulation and apparently experienced a thermal event between test cycle 10 and 20. This dryer was received in the used state and contained lint deposits in the base and in the heater pan. The lint in the heater pan was deposited on the left side of the back wall of the heater pan in a radial fan pattern, on the top outer edge of the pan, around the bearing hitch in the center, and in the bottom of the heater pan. Figure 15 is a photograph from the Wright Group hard drive.[74] The lint on the left side of the pan that continues in the fan around to the 2 o'clock position is darkened and discolored due to thermal

[73] UL 2158, AHAM Household Tumble Type Clothes Dryers HLD-1-1992.

[74] Wright Group Production Hard Drive, \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Lint Accumulation Testing_ 2011\ 1 Photos_lint accumulation Electrolux gas Used_may 2011.pdf

degradation from high temperature exposure. The lint that has deposited in the center of the pan around the hitch and in the base of the pan is gray and does not appear to be discolored. This non-discolored appearance is consistent with cooling of the air stream due to additional fresh, cooler air from the cabinet entering the heater pan through the bearing opening. Some larger chunks of lint appear to have fallen on top of the non-thermally degraded lint at the bottom of the pan as a result of transport, not operation of the dryer. If these deposits fell into this location during operation prior to transport, they would likely be covered with non-thermally degraded lint, but they are not. The duration of exposure of the discolored lint to high temperature air cannot be determined from looking at the lint. It may have been due to a few cycles or it could be evidence of prolonged poor ventilation effects.

Page 43 of 550 in "1 Photos_lint accumulation Electrolux gas Used_may 2011.pdf"

Figure 15. Pre-test image of the heater pan from the used dryer 2000 Frigidaire Model FDG648GHS0 (S/N XD01904902).

The test photographs indicate that the test process has significantly increased the rate of lint accumulation in the heater pan. This dryer was 11 years old (manufactured in May 2000 and tests conducted in May 2011) at the time of the testing. The prior installation, operational history, and maintenance history were not reported. However, the heater pan contained some lint accumulation from its life of use. Since the dryer airflow performance was not characterized prior to the start of their testing in 2011, I cannot refute the hypothesis that the Wright Group's manipulation of the dryer (i.e., disassembly, modification, and reassembly) created leaks that were not previously present in the dryer system. As depicted in Figure 16, after 10 cycles with the large, new blue cotton towel load, the quantity of lint that had accumulated in the heater pan was disproportionately much greater than that present from the prior life of the dryer. The thermally-degraded lint accumulation on the vertical, left surface of the heater pan has significantly increased along with the non-thermally degraded lint in the bottom of the pan. This disparity is an indication that the combination of ventilation change, disassembly/ reassembly process, and drum load may all have played a role in the test outcome. The other new, unused dryers do not have such a comparison base since they were new.

Page 263 of 550 in "1 Photos_lint accumulation Electrolux gas Used_may 2011.pdf"

Figure 16. Image of the heater pan from the used dryer 2000 Frigidaire Model FDG648GHS0 (S/N XD01904902) after 10 drying cycles with a large 12-pound load of new, unused cotton towels.

This dryer then displayed evidence of high temperature in the heater pan that occurred between cycle 10 and cycle 20. The blue towels were replaced with new, unused yellow towels. The top surface of the accumulated lint in the bottom of the heater pan was blackened and thermally degraded with a top coating of non-degraded yellow lint as depicted in Figure 17. The plastic bearing support was also melted and blackened. From these photos, it is apparent that the air temperature in the heater pan was significantly higher than previous cycles for some period of time during cycles 11 to 20. Mr. Parsons of the Wright Group testified in the Power matter that he believed that this test was evidence of the fire cause scenario based on the blackened lint in the heater pan.[75] He testified that about five minutes into the cycle, he and Mr. Stoddard were in the laboratory area and heard an unusual, loud noise. They investigated and did not identify any external signs of an issue with the test dryer such as smoke or other noises. After the test, he believed that this noise was evidence of the ignition event.

[75] Deposition of Ronald Parsons in the Power matter, pages 199-208.

Figure 17. Image of the heater pan from the used dryer 2000 Frigidaire Model FDG648GHS0 (S/N XD01904902) after 10 drying cycles with a large 12-pound load of new, unused cotton towels.

The ignition and fire growth scenario proposed by the Wright Group would not generate an audible noise beyond that of normal dryer operation. I believe that if the noise was associated with this test, that it was likely an indication of a propane-fueled burner misfire. Sputtering or delayed ignition of accumulated gas may cause an audible noise by shaking the appliance or by making a popping noise with ignition of the gas. The system was fueled by what appears to be a standard 20-pound LP gas grill cylinder. For an LP cylinder, the pressurized liquid boils inside the cylinder to generate vapor propane gas. This boiling process will affect the temperature of the liquefied gas and may affect the gas supply rate over a prolonged test. The Wright Group did not demonstrate that this type of fueling operation will provide a consistent and stable gas flow over a prolonged test (at least 6 hours of operation between the start of test 11 and test 17) similar to that provided by a residential propane or natural gas supply system. Further, variability in cylinders, changing of cylinders, the cylinder regulator, or the burner air shutter setting may also affect the characteristics of the burner flame. These are potential reasons that could lead to higher than normal air temperature in the heater pan that may cause thermal degradation of more lint than normal.

I cannot refute the role of these gas system factors because they were not documented or tested. Based on my experience and the Wright Group's tests of ignited lint in the heater pan for operating dryers, the lint in the bottom of the heater pan should have been consumed if it was ignited, especially if it was ignited at the start of the cycle as Mr. Parsons inferred. Forced convection by the dryer airflow through the heater pan across a burning lint deposit will cause the deposit to erode and will eventually consume all or most of the deposit. The photographs documented the presence of undamaged lint (blue and gray) under the top layer of thermally-degraded blackened lint. There was no evidence of burned embers of lint that would have been

liberated from a burning deposit in the heater pan in the lint screen samples documented during the tests. Thus, the blackened, thermally-degraded lint did not burn during this test.

3.2.4 Fire Growth When Applying the Wright Group's Hypothesis

The Wright Group has preferentially selected their current hypothesis in this matter and in many of the other cases I have reviewed. They routinely opine that the first item ignited in an individual dryer fire is lint accumulated behind the drum without sufficient evidence to support this opinion or refute other hypotheses. I will discuss the scientific inconsistencies in their approach to evaluating the weight of various fire cause hypotheses in Section 3.3. First, in this section, I will discuss the significance of their past full scale fire tests and the insights that can be drawn about fire growth when applying their hypothetical lint ignition scenario. The full scale fire tests demonstrate the dynamics of a lint-fueled fire if it originates in the heater pan and behind the drum. Second, I will discuss recent internal base fire testing performed by the Wright Group in October, 2013. This latter testing unambiguously demonstrates fire growth and damage patterns that involve ignition of lint in the dryer base and do not involve lint behind the drum or in the front air duct.

The Wright Group has not demonstrated that a naturally-occurring excessive accumulation of lint in the heater pan or the drum baffle can be ignited during dryer operation; thus, they have performed several tests where they have forced ignition of artificially placed lint[76] deposits. They have documented some tests, which illustrate the dynamics of fire growth within a dryer after lint has ignited behind the drum. I conducted a series of tests attempting to use lint placed at the heating element to ignite lint in the baffle behind the drum in electrically-heated dryers.[77] I have also personally witnessed fire testing by others to attempt to replicate the Wright Group's fire growth scenario.[78]

The Wright Group has conducted many tests of various aspects of their general excessive lint accumulation and hypothetical ignition behind the drum scenarios. The majority of the fire-related tests have demonstrated an already known conclusion—that combustible lint and other materials burn when ignited. In tests where lint was ignited in the baffle or heater pan in an operating dryer, this lint was consumed. There should be no doubt that lint will burn and can act as a bridge fuel to cause the drum load and plastic components to burn inside a clothes dryer under certain scenarios. However, their tests demonstrate very clearly that ignition of lint behind the drum <u>sometimes</u> leads to a larger fire. When it does, the drum load is the next fuel ignited and only later in fire growth do lint and plastic in the downstream air system become involved in the fire. None of their many tests have demonstrated that burning lint embers can bypass the load or bypass the lint screen then ignite lint in the air duct and fan housing.

The Wright Group's alleged fire cause hypothesis requires the ignition of excessive amounts of lint located in the heater pan or baffle, or adhered to the rear of the drum, either by the gas

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[76] The Wright Group has used lint and also cotton batting as a lint analog.

[77] Morrison DR, Ogle RA, MacDonald M. Assessing electric dryer lint fire cause scenarios. 2004 International Appliance Technical Conference, March 2004.

[78] Investigating Residential Dryer Fires, 2007 Symposium, April 17-18, 2007, Fire Findings Laboratories, Benton Harbor, Michigan.

burner or the electrical heating element. In order for the Wright Group's hypothesis to be confirmed as the cause of an individual fire, it must be demonstrated to be "uniquely consistent with the facts, and with the principles of science."[79] The Wright Group has attempted to recreate their fire cause hypothesis in two of their produced tests. However, a comparison between the fire progression shown in their testing with the evidence in individual cases typically refutes the hypothesis in these cases.

3.2.4.1 2007 Fire Test

The fire set in the testing by the Wright Group titled "WGI Electrolux burn tests 09-14-2007" involved a used electrically-heated dryer with a sagged heating element and a damaged heater pan as shown in Figure 18. This test was documented through a series of pre-test and post-test photographs and an external video.

The dryer was a Model GLER331AS1, Serial No. XD241017123, which was five years old at the time of the test. The prior history of the dryer was not documented. The initial appearance of the heater pan is consistent with inadequate airflow causing a local high-temperature region at the top of the heating element, which discolored the heater pan. This high-temperature exposure apparently led to a fracture in the top of the heater pan housing. The heater pan and baffle had insignificant quantities of lint, which would not pose a fire risk. However, the excessive accumulations of lint inside the cabinet, in the exhaust tube, and on the outside of the inlet air grill indicate that the dryer likely had restricted exhaust, which caused lint leakage outside the appliance. The observations support the conclusion that high temperature at the top of the heater pan was likely caused by restricted venting; however, there was no significant lint accumulation in the heater pan or baffle.

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[79] NFPA 921 Guide for Fire and Explosion Investigations, 2011 edition, 4.3.6.

Images from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\photos\09-11-2007_pre-fire photos, IMG_0275.jpg (above) and IMG_0291.jpg (below)

Figure 18. Heater pan used in the Wright Group Electrolux burn test 09-14-2007 with sagged heating coil and cracked heater pan.

Although the heater pan did not contain any lint accumulation before the test, the air duct and base of the dryer had significant lint accumulations. For the test, the Wright Group packed the baffle, top side and behind the top of the heater pan, and lint screen with cotton balls as shown in Figure 19. I have not seen a similar accumulation or evidence of a burned accumulation of lint in any of the dryers or discovery documents that I have reviewed; thus, I could not confirm their basis for placement behind the top of the heater pan. The dryer drum was loaded with dry bath towels and operated during the test.

\ Images from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\photos\09-11-2007_pre-fire photos, Top left: IMG_0348.jpg,Top right: IMG_0359.jpg, Bottom left: IMG_0361.jpg, Bottom Right IMG_0363.jpg

Figure 19. Cotton locations.

No detailed test notes were provided, so it is unknown what other modifications may have been made to the dryer. No internal cameras were used in this test, so fire growth had to be inferred from external observations. The dryer appeared to be leaning forward as initially oriented on the test platform since the door tended to swing forward, but its level orientation could not be confirmed from the available information. This test was conducted in an outdoors environment, and external wind clearly affected smoke flow and ventilation. External wind effects could not be eliminated as significantly contributing to the internal fire growth of the appliance after the blower ceased function.

Approximately seven and a half minutes after the dryer was started, smoke was observed blowing out of the exterior exhaust duct. Approximately two minutes later, smoke ceased to flow out of the exhaust and instead appeared out of the top of the control console, the dryer door, and the corners of the dryer as shown in Figure 20. Since the smoke was no longer being blown out of the exhaust duct, either the motor was de-energized or the blower was damaged. No external evidence of electrical shorting was observed.

Approximately nine minutes after smoke first appeared, the first discoloration of the paint above the door was observed due to smoke leaking from the top of the door. Approximately two minutes later, discoloration of the paint below the door began as shown in Figure 21. Given that the first discoloration of the cabinet paint occurred above the door, it is logical to assume that the drum load, dry towels, was the first fuel package involved after ignition of the cotton at the heater pan.

The dryer is then left to burn for approximately another 19 minutes after which the drum door was opened and flames rolled out of the drum as shown in Figure 22. When the dryer drum was opened, the burning drum load was ventilated leading to the flare-up.

No photographs of the post fire state of the entire heater pan, baffle cabinet base, or front panel were provided. The top of the heater pan, showing consumption of the cotton balls and obvious residue is shown in Figure 23.

Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\video\Electrolux-Dryer_Complete-Burn_2007_Clips

Figure 20. Approximately eight and a half minutes into the test, smoke is no longer being blown out of the exhaust duct.

Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\video\Electrolux-Dryer_Complete-Burn_2007_Clips

Figure 21. Discoloration of paint.

Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\video\Electrolux-Dryer_Complete-Burn_2007_Clips

Figure 22. Flames leaving the drum.

Images from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\photos\09-14-2007_post-fire photos, IMG_0019.jpg

Figure 23. Area behind the heater pan after the fire test.

Given the high temperature of the heater pan and heating element, it is impossible for combustible lint deposits to grow to the size simulated by the Wright Group on top of heater pan. I have not observed a fire pattern in any Electrolux-manufactured dryers consistent with

lint accumulation and combustion in this location. Nevertheless, the forced ignition of this cotton likely caused burning embers to be carried into the drum. The towel load was significantly involved and partly consumed as shown in Figure 24. Once the load was involved, it was able to spread the fire to the plastic air duct and blower after the blower ceased operating. If the downstream plastic air duct and blower had been ignited before the load, then discoloration of the paint in the lower right corner would be expected prior to the damage above the door. This progression supports the logical fire growth from the drum load then to other plastic components in the dryer.

During the test, after the front air duct and blower were apparently involved in the fire, burning drips of molten plastic were initially observed at the front right corner of the appliance. These burning drips initially self-extinguished until the internal fire caused sufficient heat output into the flooring under the dryer that a small pool fire was created. The apparent damage to the bottom of the dryer, as indicated by the fire pattern on the platform that extended beyond the dryer on all sides, was quite unusual based on the other Electrolux-manufactured dryers that have been involved in fires. Most of these dryers have a small, local area of damage underneath the dryer's front right corner where the steel panel is holding burning plastic inside the dryer. I cannot recall examining any other dryer in an isolated fire where the entire underside has caused fire damage similar to this. Given the limited information available on the test conditions and my experience, my inference is that the wind-ventilated conditions and potentially a non-level orientation caused unusual fire behavior in this test.

Images from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\photos\09-14-2007_setup & towels\photos.pdf, IMG_0007.jpg (Top), F:\DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI Electrolux burn tests 09-14-2007\photos\09-14-2007_post-fire photos\photos.pdf, IMG_1031.jpg

Figure 24. Undamaged towels prior to the test and burned towels after the test.

3.2.4.2 2008 Fire Test

The Wright Group materials documented a series of 43 tests performed for Travelers Insurance in 2008. Again, an electric dryer was utilized for the test. Cotton batting, lint, and cotton balls were packed into the baffle, as shown in Figure 25, and placed on the bottom of the heater pan and on the ball-hitch. The exhaust was restricted by 50% and after turning the dryer on, additional masses of lint were dropped onto the heating element until ignition was achieved.

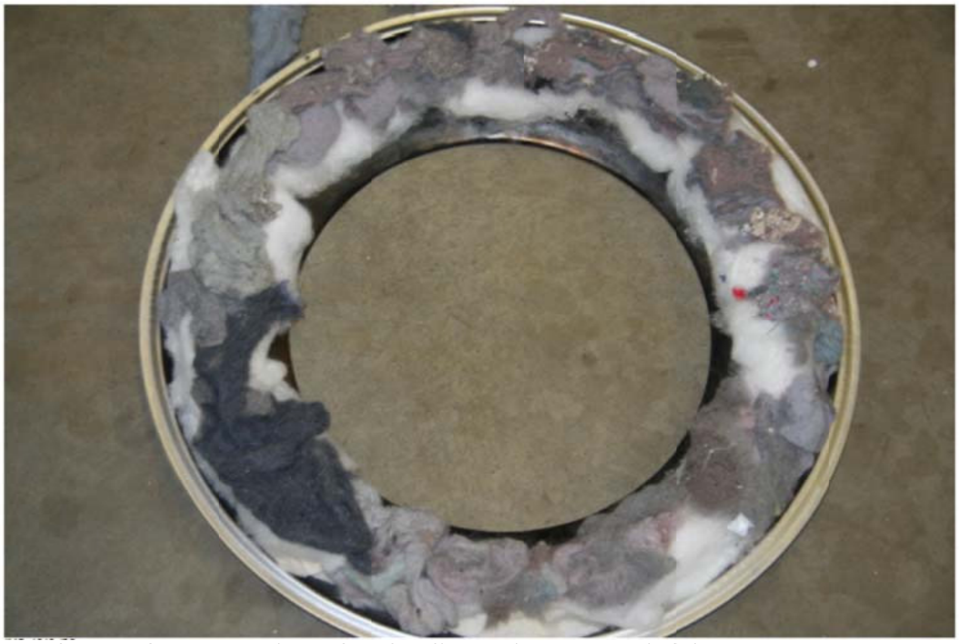

Image from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI & Traveler's_Electrolux_Dryer Testing Nov_Dec 2008\Test43_photo_1setup\photos pdf.pdf, IMG_1246.jpg

Figure 25. Lint and cotton packed into the baffle.

The fifth mass of lint dropped onto the heating element was able to ignite the lint packed into the baffle. Within a few seconds, this burning lint ignited the tumbling towel load. Approximately two minutes later, burning embers could be seen entering the air duct and flaming ignition of lint on the lint screen was observed as shown in Figure 26.

Video from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI & Traveler's_Electrolux_Dryer Testing Nov_Dec 2008\Test43_video
Image exposure lightened

Figure 26. Sparks and burning lint in the air duct.

The drum continued to turn and the blower continues to pull air through the drum and front air duct. Approximately three minutes after the initial ignition, the motor stopped rotating the drum and blower. At that point, no more combustion is observed in the air duct and the load becomes fully involved in a fire. The plastic components of the air duct and blower are not damaged at this point in the fire.

The paint above the drum door began to discolor approximately four minutes after fire initiation and one minute after the drum stopped turning. The drum load then burned for another one to two minutes before the plastic of the air grill began to melt and flow into the air duct and eventually onto the cabinet floor. Throughout this time, the lint in the air duct, the air duct itself, and the blower housing did not ignite (Figure 27).

Video from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI & Traveler's_Electrolux_Dryer Testing Nov_Dec 2008\Test43_video

Figure 27. Drum fire causing melted plastic of the air grill dripping into the air duct. Lint in the air duct is not ignited.

At approximately six minutes after fire ignition, the motor restarted causing the drum to turn and fire to be drawn into the air duct as shown in Figure 28.

Video from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI & Traveler's_Electrolux_Dryer Testing Nov_Dec 2008\Test43_video

Figure 28. Blower motor restarts and pulls drum fire into the air duct.

The blower continued to pull flames into the air duct for approximately 15 seconds after which the fire continued to burn in the drum, but no flames were observed in the air duct. After another minute, the fire began to burn down into the top portion of the duct. Fire was then observed on the base of the dryer as shown in Figure 29. Noticeably, the blower housing is damaged from the top down as the cabinet filled with the hot combustion gases from the burning load in the drum above. Eventually the entire air duct became involved in the fire. Over nine minutes after fire initiation, the bottom of the air duct began to melt and sag to the bottom of the dryer cabinet. The drum door was opened, and the fire was extinguished 11 minutes after ignition.

Video from Wright Group Hard Drive: \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI & Traveler's_Electrolux_Dryer Testing Nov_Dec 2008\Test43_video

Figure 29. Flames visible in the top portion of the air duct and in the base of the dryer.

The fire growth observed in the 2008 Wright Group and Traveler's testing disproves Mr. Stoddard's hypothesis that after ignition of lint behind the drum that the lint in the plastic air duct can directly ignite without involvement of the drum load. On the contrary, the drum load burned for an extended period of time before the drum fire ignited the plastic air duct and blower. Even a temporary restart of the blower that drew flames into the air duct for 15 seconds was not sufficient to ignite the air duct or blower housing.

3.2.4.3 2013 Base Fire Test

The Wright Group conducted a base fire test on a ball-hitch dryer on October 31, 2013.[80] From a review of the test documentation, it is apparent that the test was not performed in a manner consistent with UL 2158 fire containment test provisions. However, the test demonstrated the progression of a base fire inside a ball-hitch dryer. This was the first such test that I am aware of the Wright Group performing, and the fire progression during the test is consistent with most witness observations of fire growth in past dryer fire incidents. The test did not involve any naturally-occurring lint accumulation or simulated lint accumulation in the heater pan or the baffle ring behind the drum. The test involved a simulated lint deposit at the front of the cabinet base surrounding the blower housing and front air duct.

The test dryer was an electrically-heated Model FDE21GRES1 Serial No. XD85175981 manufactured in December of 1998. The dryer appeared to be in good condition and did not contain any evidence of lint accumulations inside the cabinet, heater pan, or baffle ring. No historical usage or maintenance information was provided for the dryer. The Wright Group replaced the original steel-faced blower with an HB-rated plastic blower assembly and cleaned all lint from the cabinet. A limited arrangement of cotton cheesecloth was laid on the base of the dryer and around the blower housing. The dryer was also draped with cheesecloth as an indicator of flame escape from the cabinet. The dryer was not running during the test, an exhaust draft fan was not used, and the dryer was not energized. Flames ultimately escaped

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[80] Wright Group hard drive at \DRYERS DEPO INFO\Electrolux\Electrolux Testing\Electrolux Fire Containment Testing_October 2013\Burn Test_10-31-2013\

from the cabinet during the test. The external and internal fire patterns are consistent with patterns on fire-involved dryers that have an overall similar level of damage (see Figure 30).

Image 250 from “Burn Test 01_10-31-2013.pdf”

Figure 30. Exterior fire patterns are identical to fire damage patterns observed to most Electrolux ball-hitch dryers that have been involved in a fire incident.

The most important and new aspect of this test in comparison to the past testing performed by the Wright Group was the inclusion of simulated lint in the cabinet base. No direct experimental comparison has been made between the thickness of cheesecloth and depth of lint, which would yield a similar internal fire. However, lint in the base of the dryer should be removed during the periodic 18-month cleaning performed by an authorized service technician. The Wright Group’s alleged design defect requires lint behind the drum in the heater pan or baffle ring to be the first item ignited, which they then hypothesize leads to an internal duct fire in the front air duct or blower. As I discussed earlier, their alleged fire progression is illogical and inconsistent with their testing and my experience. In contrast, from this test, the demonstrated progression of the base fire is logical and consistent with witness observations in fire incidents and my experience.

The simulated lint base fire spread slowly across the cabinet floor with no obvious external smoke visible in the videos for several minutes after ignition. If the dryer was running and exhausting air from the cabinet, it would likely increase the duration between ignition and observation of smoke outside the cabinet. After the simulated lint fire involved the plastic blower housing and air duct, the fire was localized to the front right corner (when facing the door) of the appliance. Eventually, the fire spread toward the left and the front air duct melted and sagged into the cabinet base. Fire damage severity decreases from right to left as indicated in Figure 31 and Figure 32 taken after the fire was extinguished. The fire and damage progression are consistent with typical witness observations of the first discovery of fire in the base of a dryer observed through the lint screen housing.

Image 269 from "Burn Test 01_10-31-2013.pdf"

Figure 31. The lint screen has melted and the grill cover for the air duct is melted more toward the right side similar to fire damage patterns observed in past burned Electrolux dryers.

Image 306 from "Burn Test 01_10-31-2013.pdf"

Figure 32. Blower assembly and air duct are melted and burned with more damage toward the right side similar to fire damage patterns observed in past burned Electrolux dryers.

3.2.4.4 Conclusions from Wright Group Fire Tests

The Wright Group's tests are forced failures of clothes dryers and components and none of the tests are conducted using clothes dryers with naturally-deposited lint accumulations. The contrived circumstances of the tests do not simulate normally anticipated usage of clothes dryers or replicate any real dryer installations. Although these forced failure tests do provide some demonstrative insight into aspects the fire growth inside clothes dryers, the Wright Group has consistently misinterpreted or misapplied the information in a manner that contradicts logical fire growth, witness observations, and other factual evidence.

For example, the full scale fire tests conducted by the Wright Group indicate that if accumulated lint in the heater pan or baffle is somehow ignited, then the drum load will be the next item ignited. This finding is consistent with logical fire growth within the appliance. However, the Wright Group neglects this logic and these observations when opining on fire cause in dryers. In cases where a witness opens the drum and does not observe signs of combustion in the load or at the back of the drum, the Wright Group hypothesizes that burning embers (sometimes just a single ember is alleged) have bypassed the load and lint screen to ignite downstream lint in the air duct or blower.

The moving geometry, perforated back wall of the drum, tumbling load, air grill, lint screen, and air duct create a tortuous pathway for a burning ember to follow. Any burning embers of lint that are able to pass through the perforated back wall of the drum must successfully pass through the tumbling load to reach the lint screen. For embers to pass the lint screen, either they have to burn a hole in the screen or they must be smaller than the openings in the screen. Burning embers that pass through the air duct must have sufficient energy and contact residence time to ignite lint deposits in the blower housing. The Wright Group tests did not demonstrate that this is possible; instead, they demonstrated that if the fire spreads beyond the lint, a drum fire is the most likely outcome of ignition of lint in the heater pan and baffle. The plastic front air duct, foam seal, and blower housing did not ignite early during the fire; only significant pre-heating, melting, and fire exposure from the combustible drum load caused these items to burn.

The hypothetical burning ember(s) necessary to support the Wright Group's hypothesis would have to follow a tortuous path through small openings and combustible materials to reach the ultimate location of fire damage within the front air duct without causing ignition of the drum load along the way. This scenario is highly unlikely, if not impossible, and is not supported by any of the Wright Group's testing or any other analysis. The much more likely scenario consistent with the fire patterns and other facts is ignition of accumulated lint in the base, which leads to a fire outside of the air system. Melting of the front air duct and blower housing would then facilitate the typical witness observations of smoke, flickering, or flames in the front air duct.

Further, the base fire test demonstrated that ignition of accumulated lint in the cabinet base can lead to ignition of the internal plastic blower housing and air duct with preferential damage at the front right corner of the appliance. Subsequent fire growth will then move from the right to left if the front air duct is involved. This fire growth progression is entirely consistent with my experience and observations of dryers involved in fire incidents, especially those that have been extinguished early during fire growth, and witness observations of the incipient stages of fire growth in clothes dryers. This lint, which would serve as the first item ignited, is located in the

cabinet base area where it should be observed and removed by an authorized service technician performing routine maintenance.

These test results are consistent with my experience, the logical fire growth and fire dynamics inside a clothes dryer, and directly contradict the opinions routinely posed by Mr. Parsons and Mr. Stoddard of the Wright Group that burning lint can somehow pass by the load without igniting it and then cause ignition of lint deposits in the air duct or blower assembly.

3.3 Plaintiffs' Consultants' Frequent Disregard for Competing Fire Cause Hypotheses

The Plaintiffs' allegations of a uniform lint accumulation behind the drum, ignition, and fire growth defect due to the design of Electrolux-manufactured dryers is not supported by the balance of physical evidence, testing, or logical fire growth. This alleged design defect is largely based on testing and analysis conducted by the Wright Group in the past. As I discussed in the prior section on lint accumulation, gas-heated and electrically-heated dryers have different heating system configurations and in cases where lint has accumulated in this area, it varies in location, quantity, and appearance. In many cases, there is no evidence of a pre-fire excessive accumulation of lint in the heater pan area or behind the drum. Nevertheless, the Wright Group has frequently alleged that lint behind the drum has served as the first item ignited in individual fires, and but for this lint, there would have been no fire.

The Wright Group has proposed a general group of fire ignition and growth hypotheses in the past and in the present matter. Reasonable fire ignition and growth hypotheses explain the circumstances leading to ignition of the first fuel and how that initial fire grows to include other fuels in the system. Although an individual scenario may be difficult to replicate through laboratory testing alone, logic-based analysis, an understanding of fire dynamics, and inferences drawn from tests can be used to refute ignition and fire growth hypotheses as part of the scientific method of fire investigation. The Wright Group has not scientifically demonstrated that their fire cause and progression hypothesis is valid by demonstrating that all of the individual steps are possible. There are at least two gaps in logic in their fire growth scenarios: (i) initial ignition of lint somewhere behind the drum and (ii) embers bypassing the load (and the lint screen) to directly cause ignition of lint in the front air duct and/or blower housing.

They have ignored numerous other, more likely, credible fire cause hypotheses in favor of a fire cause hypothesis that matches their defect allegations. Fire cause hypotheses must be developed and evaluated based on the facts of the individual case under investigation. However, from past investigations and the current dryer investigations, Mr. Parsons and Mr. Stoddard have neglected the facts and fire dynamics in order to offer a design defect allegation as the cause of the fires.

The Wright Group have routinely employed nonscientific, biased approaches in determining that their design defect hypothesis is the cause of the fires while ignoring the physical evidence and witness observations that indicate otherwise. Two types of scientific bias described in NFPA 921 can be applied to their past investigation findings and their investigations of the named Plaintiff dryers: expectation bias and confirmation bias.

Expectation bias, as defined by NFPA 921, is:

> **4.3.9 Expectation Bias**. Expectation bias is a well-established phenomenon that occurs in scientific analysis when investigator(s) reach a premature conclusion without having examined or considered all of the relevant data. Instead of collecting and examining all of the data in a logical and unbiased manner to reach a scientifically reliable conclusion, the investigator(s) uses the premature determination to dictate investigative processes, analyses, and, ultimately, conclusions, in a way that is not scientifically valid. The introduction of expectation bias into the investigation results in the use of only that data that supports this previously formed conclusion and often results in the misinterpretation and/or the discarding of data that does not support the original opinion. Investigators are strongly cautioned to avoid expectation bias through proper use of the scientific method.[81]

It is clear, through my evaluation of the Wright Group's reports, that they have chosen which evidence to rely on based upon their defect hypothesis. By ignoring evidence that does not fit their predetermined lint accumulation and ignition hypothesis, they have dismissed other potential ignition scenarios and incorrectly evaluated the fire cause.

Furthermore, Mr. Parsons and Mr. Stoddard routinely neglect the Wright Group's own test results, which have indicated that if a fire grows in a dryer after lint behind the drum is ignited, then the drum load will be the second item ignited. The HB-rated plastic materials constructing the front air duct and the blower assembly were not easily ignited by a lint fire and were not ignited by burning embers passing through the air duct. They routinely have failed to evaluate, test, and refute other more likely fire cause scenarios because they expect that the fire was caused by a design defect leading to lint accumulation and ignition behind the dryer drum.

Furthermore, Mr. Parsons and Mr. Stoddard also employ confirmation bias as defined below:

> **4.3.9* Confirmation Bias**. Different hypotheses may be compatible with the same data. When using the scientific method, testing of hypotheses should be designed to disprove the hypothesis. Confirmation bias occurs when the investigator instead tries to prove the hypothesis. This can result in failure to consider alternate hypotheses. A hypothesis can be said to be valid only when rigorous testing has failed to disprove the hypothesis.[82]

Instead of attempting to refute all reasonable fire cause hypotheses, the Wright Group begins their analyses with their defect hypothesis. Their physical testing and logical analysis has focused solely on proving their defect hypothesis. The Wright Group has consistently correlated the presence of lint (regardless of the quantity, location, or appearance) in a burned clothes dryer as validating their design defect and ignition hypothesis. They have disregarded the fire dynamics as demonstrated through their testing, logical understanding of fire dynamics, and have failed to test other lint-fire cause scenarios in the base area of the dryer.

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[81] NFPA 921 Guide for Fire and Explosion Investigations, 2011 edition.

[82] NFPA 921 Guide for Fire and Explosion Investigations, 2011 edition.

4 Clothes Dryer Fire Risk Analysis

The fire risk posed by an individual consumer product is a function of the severity of a specific hazardous consequence and the probability or likelihood of achieving that consequence. Each step in the sequence of events leading to the consequence may be quantified through statistical data, testing, and technical judgment. The potential fire risk posed by a specific product can be evaluated by analysis of particular fire scenarios, which are the distinct sequences of events (e.g., human actions, mechanical failures, and environmental conditions) that lead to the ultimate fire outcome. There is no industry-wide standard for product fire risk analysis; however, a consumer product fire risk analysis generally contains the following elements:[83,84,85,86,87,88]

1. Specify goals, objectives, and measures of the analysis
2. Define assumptions in the analysis
3. Specify the relevant scenarios
4. Perform tests and/or analyses to quantify and/or qualify the probability and severity of each scenario.

An objective analysis of fire risk in clothes dryers is quite complex. While logic, experience, testing, and fire incident investigation all provide bases on which to develop failure modes that lead to fires, there are no objective scientific or statistical data available to complete the risk analysis. Thus, an analyst must use judgment and experience to compare the relative probability of an individual fire incident with the presence of a specific aspect of product design or installation through the use of a hazard analysis.

At the minimum, an objective analysis must consider numerous interrelated factors, each of which are comprised of their own subset of interrelated factors. These factors must describe the fuel(s) for the fire, the first item ignited, the ignition source, and the cause for interaction between the ignition source and the first item ignited. The diagram presented in Figure 33 illustrates some common high level elements that comprise the interrelated fire risk factors and begins to demonstrate the complexity of the relationships.

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83 "Section Five, Chapter 1 – Introduction to Fire Risk Analysis," John M. Watts, Jr. and John R. Hall, Jr., SFPE Handbook of Fire Protection Engineering Third Edition, 2002.

84 "Section Five, Chapter 11 – Product Fire Risk," John R. Hall, Jr., SFPE Handbook of Fire Protection Engineering Third Edition, 2002.

85 "Framework Model of Product Risk Assessment," *International Journal of Injury Control and Safety Promotion*, Vol. 16, No. 2, June 2009.

86 International Standard ISO 14121-1999(E), "Safety of Machinery – Principles of Risk Assessment."

87 Risk Assessment – Basics and Benchmarks, Bruce W. Main, 2007.

88 NFPA 551, "Guide for Evaluation of Fire Risk Assessments," 2007.

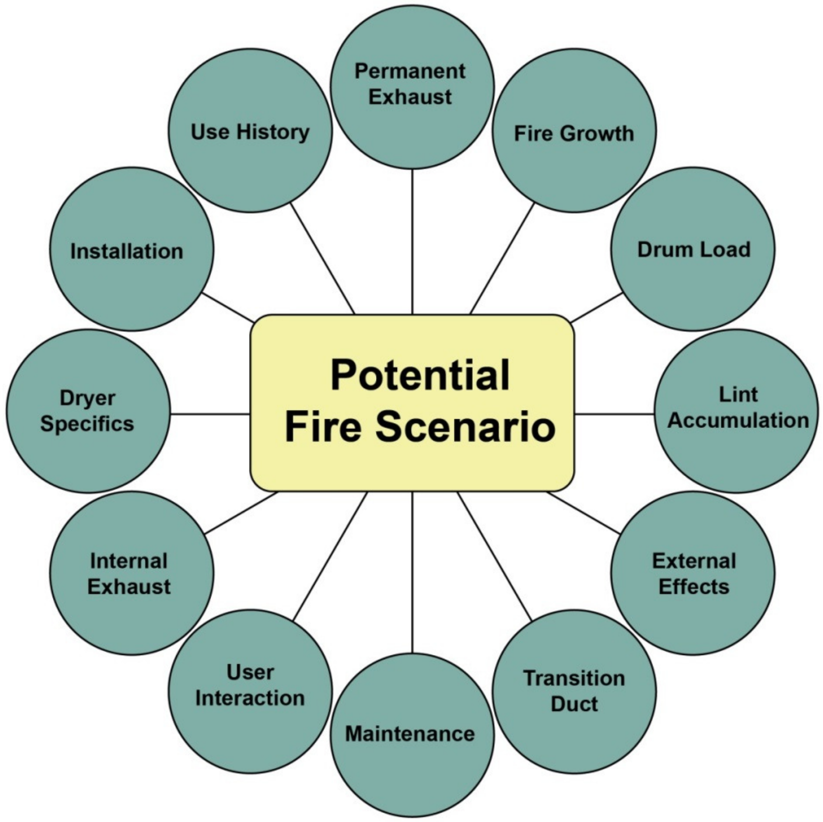

Figure 33. Factors that contribute to potential fire scenarios.

Techniques for hazard analysis may be either qualitative or quantitative. The type of technique chosen typically relates to the problem under study and the objectives of the analysis. The risk analysis team may use experience, judgment, and industry guidelines to define failure scenarios. Typical techniques used in product risk analyses include Cause & Effect Logic Diagrams (CELD, also referred to as Ishikawa Diagrams, or Fishbone Diagrams), Fault Tree Analysis (FTA), Failure Mode and Effects Analysis (FMEA), and Failure Mode, Effects, and Criticality Analysis (FMECA). CELDs are used to organize logic-based evaluations of potential product failure modes. FTAs are used to perform detailed failure analysis and can include the use of the probability of failure or occurrence of individual components. When probabilities are employed with FTA, the relative likelihood for potential failure modes can be compared. Specific fire scenarios can be evaluated through construction of Fault Trees such as that shown in Figure 34.

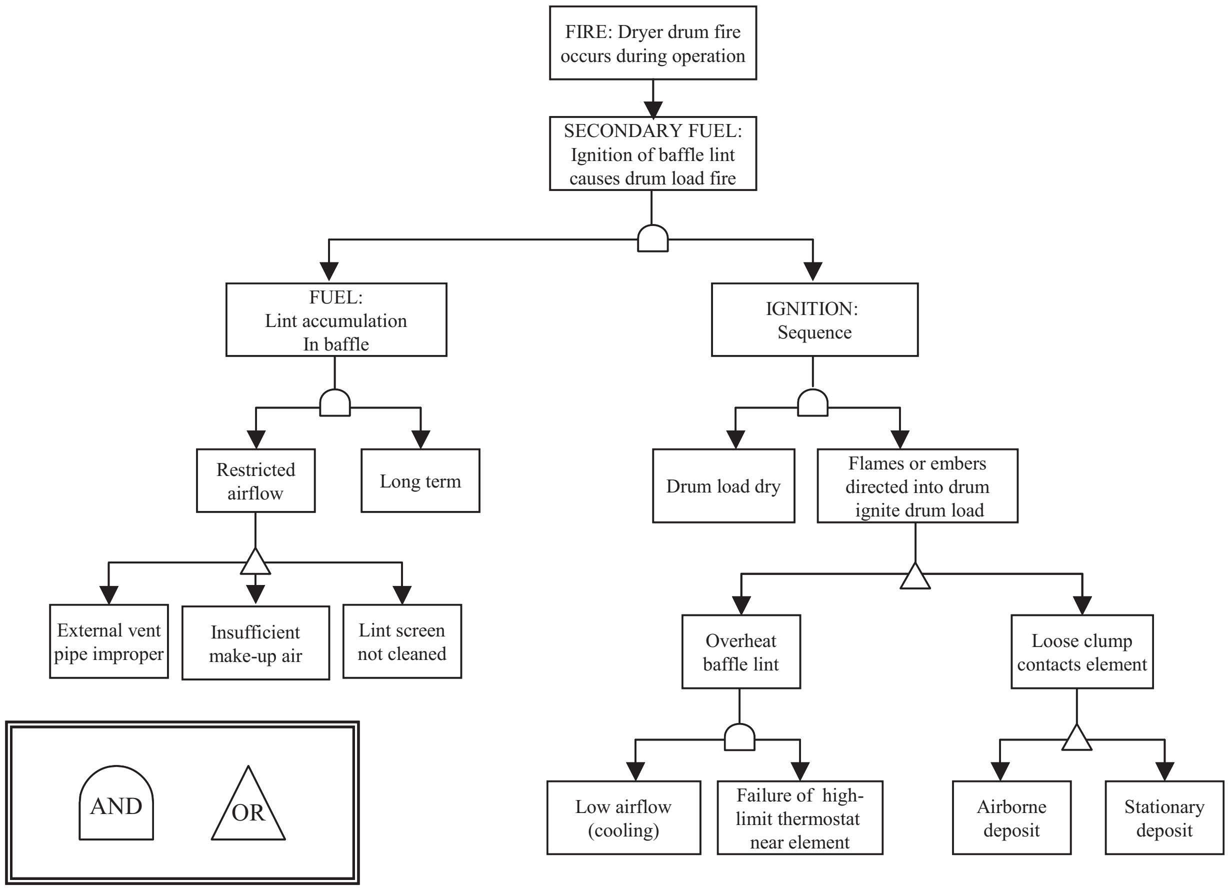

Figure 34. Baffle lint ignition fault tree diagram.[89]

FMEA is a team-based hazard analysis methodology where an engineered system is evaluated on a component-by-component basis to identify potential single-point failure modes and their effects on the system. FMECA is similar to FMEA, but it uses quantitative criteria to calculate the relative criticality of each failure mode. The criticality is a relative measure of a failure mode and its frequency of occurrence. A Design FMECA, such as those conducted by Electrolux for the Alliance dryer and the GE dryer design program, is conducted during the process of designing a product. The Design FMECA is complete after the system design specifications have been completed. Only a few examples of the Design FMECA worksheets were provided in the discovery file. These appeared to be intermediate work product and only provide a small sample of the Design FMECA process.

Engaging in a FMEA or FMECA requires the definition of a specific component failure mode and its effect. The failure mode is the single-point, functional failure of the component not the failure mechanism. For example, the failure mechanism of a snap action thermostat might be the fusing of contacts due to internal contamination. Multiple failure mechanisms may lead to a single failure mode. The failure mode is the functional failure, i.e., failure to function for the device. For a clothes dryer high-limit thermostat example, the normal mode of operation is for

[89] Morrison DR, Ogle RA, MacDonald M. Assessing electric dryer lint fire cause scenarios. 2004 International Appliance Technical Conference, March 2004.

the thermostat to remain closed at operating temperature, to open at a high temperature set point, and then to close again after the temperature has dropped a defined amount. Failure modes for the thermostat are the opposite of the desired function.

1. The thermostat is open at normal temperatures leading to inability of the dryer to heat the drum load.
2. The thermostat fails to open at the high temperature set point.
    a. If the dryer is adequately vented and this is an unusual event, no hazardous outcome may be present.
    b. If the dryer is not adequately vented and commonly runs overheated, then damage to the drum load or in some cases, ignition may be possible.
3. The thermostat fails to close (reset) after the air temperature cools leading to the inability of the dryer to heat the drum load.

4.1 Factors Affecting the Fire Risk

Within an individual clothes dryer, the primary fuels are the garment load, lint, plastic components, and the fuel gas for gas-heated units. The allegations in this matter center on the ignition of accumulated lint within an individual appliance that leads to fire within the unit. There could be many causes of a lint fire: lack of cleaning, electrical component failure, spontaneous combustion of an idle drum load, or something else outside the appliance in the laundry room. Moreover, often one cannot identify a single factor that caused the fire. Instead, the fire is caused by a unique and complicated interaction between several factors. Factors one should consider when developing and analyzing a potential clothes dryer fire risk scenario include those listed in Table 1. Investigation and analysis of a single dryer fire may reveal the interplay of various factors that contributed to that fire, but one cannot generalize about the interplay of such factors in all dryer fires because of the varied circumstances of any fire. Fire risk analysis involves many factors that interact differently in different scenarios. Focusing on only one factor to the exclusion of others grossly oversimplifies a potential fire hazard evaluation.

The installation and ongoing maintenance of the clothes dryer and exhaust system are the most prominent risk factors relating to clothes dryers. These factors are outside of the control of the manufacturer, and over the lifetime of an individual clothes dryer, these factors will affect the potential fire risk in an unquantifiable manner. In the following sections, I will discuss an objective approach to evaluating this fire risk and contrast that to the subjective approach that the Plaintiffs have undertaken.

Table 1. List of many factors that affect the fire risk in an individual clothes dryer.

Clothes Dryer Specifics—Manufacturer, Model, Features	Use History	Permanent Exhaust System	Installation
Blower characteristics Lint screen system design Internal ducting configuration Internal seals—drum, blower housing, ducting Heater design—location, type (i.e., gas or electric), configuration, deflectors Operating controls Safety controls Baseline failure rates of all components in an adequately exhausted dryer	Types of garments—cotton, synthetic, clothing, bath towels, bedding, rugs, other items Fabric softener type, frequency, quantity Clothes washer wear effects on garment/linens Cleaning the lint screen Number of loads Size of loads and frequency of loads Drying cycle temperature and duration settings Load contamination	Type of construction—rigid, semi-rigid, flexible Length, number and type of elbows and/or bends Configuration (e.g., sagging, vertical rises/drops) Type of external vent cover Location of external vent cover—external impacts/effects Age and cleaning history Seals between component sections Physical condition/defects—screws, foreign materials, dents Exhaust booster fans Routing—inside conditioned space, unconditioned space, combination, exhaust diverters into dryer space	Moving or adjusting the appliance Physical proximity of dryer exhaust tube exit and permanent exhaust tube entrance Make-up air to clothes dryer—to laundry room, tightness of home construction, doors on alcove or closet Access to the dryer exhaust tube Access to the permanent exhaust duct Connection method of transition duct to dryer and permanent exhaust duct Effectiveness of sealing method for transition duct connections Power supply (e.g., power saving appliance that slowed the fan, issues with outlet)? Gas supply (e.g., type, pressure, regulator)? Installation location (e.g., garage, unconditioned space)? Modifications to internal components (e.g., propane kit, side vent, etc.)? Spread of fire to structure Fuel sources
Lint Accumulation	**Maintenance**	**Transition Duct**	
Quantity and location Outside the cabinet Inside the cabinet—specific location (e.g., floor, walls, on/near heater) Internal ducts Transition duct Permanent exhaust duct	Routine cleaning of the dryer cabinet Routine cleaning of the exhaust system Routine cleaning outside the dryer cabinet Duration between cleanings Repair/replacement of damaged components Mechanical wear to components	Type of construction—rigid, semi-rigid, flexible Length, number and type of elbows and/or bends, special fittings (e.g., periscopes) Configuration (e.g., sagging, vertical rises/drops) Type of seal/joining between sections, to clothes dryer, and to permanent exhaust duct	

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4.2 Evaluating the Fire Risk for Electrolux Clothes Dryers

The Wright Group alleges that the fire risk for Electrolux-manufactured dryers is unreasonable. This allegation is based upon their analysis of the discovery documents and investigation of prior clothes dryer fires. Their bases for this assertion appear to rely substantially on historical fire investigations conducted by the Wright Group and others. No external statistical information such as that provided by the NFPA was mentioned in the reports by the Wright Group. As I will discuss below, the Plaintiffs' consultants did not undertake an objective, scientific analysis in order to provide a basis for this assertion.

To analyze the residual fire risk posed by a product, the key parameter to understand is the probability of an individual unit being involved in a fire. The implicit assumption in this analysis is that the individual unit was a factor in the ignition of the fire and not just a witness or additional fuel in an exterior-initiated fire event. The outcome of individual fire incidents can vary widely between a loss of function in the appliance and a structural fire in a residence depending upon many incident-specific factors as annotated above.

The Wright Group report refers to the "basic principles of safety engineering" several times in their report, which is also referred to as the safety hierarchy. Mr. Parsons and Mr. Stoddard are critical of the Electrolux ball-hitch dryer design because Electrolux has not designed the hazard, lint, out of the appliance. As mentioned above, combustible lint is an inherent element of all vented clothes dryer operations. Lint cannot be designed out of a clothes dryer system; thus, manufacturers use design safeguards such as the high-limit thermostat to reduce the likelihood of ignition of accumulated lint and the garment load. Because of the randomness and uncertainty in any individual clothes dryer's usage and installation, manufacturers also provide an instruction to have lint cleaned from the cabinet.

Mr. Parsons and Mr. Stoddard opined on the fire risk posed by Electrolux ball-hitch dryers, and they believe that these appliances pose a higher risk than other manufacturers' bulkhead-style designs. These opinions are based on a biased sample set and experience, typically acquired through the investigation of dryers already targeted for subrogation by their clients. To support a hypothesis of a design defect such as that alleged by the Wright Group, one must perform a risk assessment to objectively evaluate the design.

The Wright Group did not directly compare the risk of Electrolux dryers to the general population of clothes dryers in the U.S. across a common or consistent data set (discussed below); instead, they have subjectively arrived at a determination of the fire risk. The Wright Group's primary basis for concluding that Electrolux ball-hitch dryers pose an unreasonable risk is their comparison to fire incidents involving non-Electrolux manufactured bulkhead style dryers; however, they have made no objective attempt to determine the fire risk posed by their supposedly safer design (either through their proposed changes, the "RONCO" prototypes, or other bulkhead dryers).

I will discuss an appropriate risk analysis for Electrolux clothes dryers and address the errors and inconsistencies that I have identified to date in the Plaintiffs' work.

4.2.1 The Wright Group's Proposed Alternative Designs Are Not Substantially Different

The Wright Group report and attachments do not indicate that they have conducted any analysis of the relative risk between the two design types (ball-hitch versus bulkhead) or the residual risk if the Electrolux design is modified (e.g., RONCO designs). However, they have proposed several design modifications to the basic ball-hitch platform that they presume to reduce the risk of a fire incident occurring. The Wright Group has not demonstrated that there would be any decrease in the residual risk of a lint fire with any style of clothes dryer given their suggested design changes.

The Wright Group has proposed that the RONCO 3 and RONCO 4 modifications to the Electrolux pan-style clothes dryer would significantly decrease the residual fire risk of the ball-hitch platform by essentially separating potential lint accumulation from direct ignition by the burner flame. The Wright Group conducted some limited testing on the design and declared that it performed satisfactorily in drying clothes when compared to the original Electrolux designs. This alternative design, however, has not been demonstrated to eliminate or mitigate the potential hazards that the Wright Group has alleged are evidence of a design defect. The Wright Group materials do not show that they have conducted enough drying cycles to simulate a reasonable life and accompanying potential for lint accumulation with this modified design. Typical consumer use estimates are on the order of 400 cycles per year; however, their material indicates on the order of 20 or less drying cycles were run for the RONCO designs. Further, no comparison of this alternative design to the UL or CSA listing requirements was performed for the RONCO dryers.

The RONCO designed separation, which elongates the heater duct, will not prevent entrained lint particles from passing through the duct and potentially collecting in the heater pan. Further, the elongated duct will likely prevent larger particles of lint from escaping the duct. If these particles are not adhered to the inside of the duct, they will fall back to the combustion chamber. This creates the potential for combustible lint accumulations to grow in the heater duct. The Wright Group does not appear to have investigated this likely outcome of the alternative design, which may actually increase the potential fire hazard over the existing Electrolux design. It is clear that not only has the Wright Group not thoroughly investigated the RONCO alternative design for fire safety ramifications, but they have not evaluated the economics or manufacturing aspects of the alternative design.

Mr. Parsons and Mr. Stoddard also opined that since sensor technology has not been incorporated into the Electrolux design to identify restricted airflow, that this is another design defect. They have not provided evidence that they are knowledgeable about sensor technology and the current state-of-the-art. Direct measurement or sensing of airflow within a clothes dryer poses challenges for reliable consumer product sensor technology. For a moist and particulate-laden airflow such as this, typical industrial sensors require sweep air to keep the sensor clear of obstructions, and even those require frequent maintenance. A recent Consumer Reports study of these types of sensors for clothes dryers concluded that the technology was not reliable enough to apply to a residential clothes dryer.[90] The Wright Group has not provided a basis supporting

[90] "Dryers", Consumer Reports Magazine, July 2010

their assertion that adequate sensing technology was available or incorporated into other manufacturers' designs during the time period when the subject appliances were manufactured.

4.2.2 Wright Group Experience Data

The Wright Group provided a tabulation comparing their number of Electrolux dryer inspections performed versus years since manufacture for the individual appliances. This Wright Group experience data set contained 141 incidents. The data are graphed in Figure 35. Their report does not indicate why their experience data represents only 141 since Mr. Parsons and Mr. Stoddard have represented in the past that the Wright Group has conducted hundreds of Electrolux dryer examinations. The experience tabulation from the Wright Group is inherently subjective; the use of these data to estimate the fire occurrences in a larger population has no scientific basis. The data are biased sets of fire cause determinations made in the process of investigating subrogation claims, and the Plaintiffs have not demonstrated a basis for opining that the Wright Group examination experience is representative of the population of Electrolux manufactured or any other brand of clothes dryers. The only statistical significance that can be placed on these data is that they represent some of the individual fire incidents that the Wright Group has been hired to investigate.

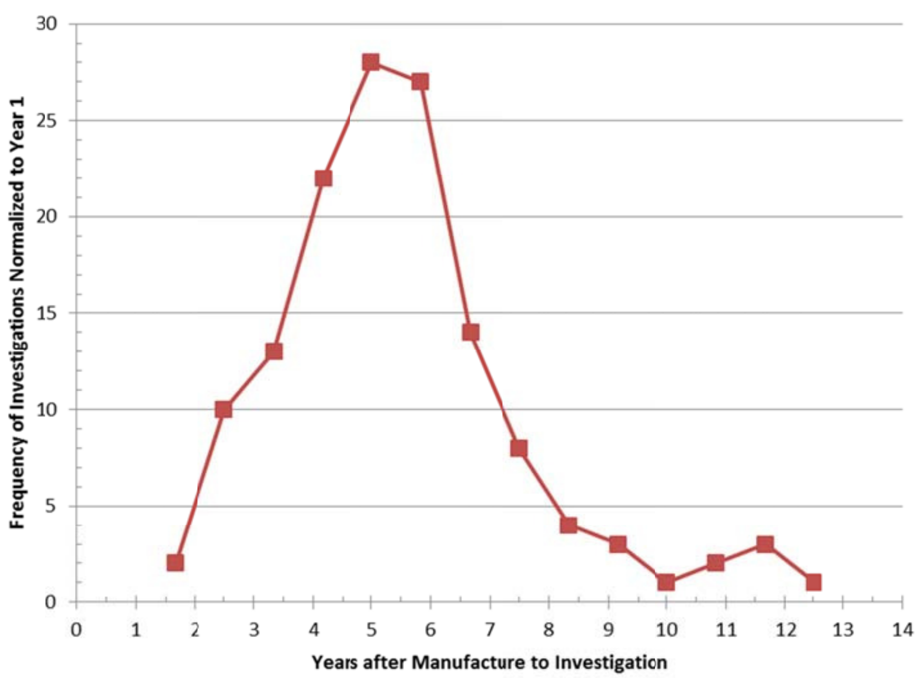

Figure 35. Wright Group (141 incidents) experience trend for number ball-hitch dryer examinations versus years from manufacture.

The Wright Group experience indicates a peak number of incidents in the region of 5 to 6 years after manufacture and drops quickly after that. Based on the experience data from the Wright Group, Mr. Parsons and Mr. Stoddard have concluded that most Electrolux dryer fires occurred 3.5 to 6 years after manufacturing and that this was somehow supportive of their opined design defects. However, the Plaintiffs have failed to provide any similar analysis for the bulkhead

style clothes dryers that the Wright Group has investigated. There is no basis for concluding that this 3.5 to 6 year time frame is any different for Electrolux clothes dryers than bulkhead dryers or that it represents the entire Electrolux dryer population.

The Wright Group also tried to rely upon the history of examinations performed by other firms to bolster their conclusions regarding the statistical significance of their examination history. For example, their file materials and report include documents produced by Travelers Insurance where Travelers reviewed 60 fire incidents from 2009.[91] The documents include a pie chart that had apparently been produced in a past case involving the Wright Group, but the materials do not provide any underlying basis for the Travelers assessment such as the total size of the data set (i.e. 60 dryer fires out of X number of dryers, Y percent of these dryers were Electrolux, etc.). The documents fail to demonstrate that the underlying data used to generate the Travelers pie chart either contained or was a representative sample of all of Travelers' 2009 fire incident claims or a representative cross-section of manufacturer market share.

The Travelers Laboratories engineer who created these documents stated that the dryer fire incident statistics were derived by quantification of <u>only</u> the appliances that were referred to Travelers Laboratories for further investigation by Travelers claims professionals.[92] The quantity of dryers in this data set is not representative of the population of all of the dryer fire incidents that Travelers insured in 2009. Without a basis that the Travelers documents are representative of all dryer fire incidents, they are useless in objectively evaluating the frequency of Electrolux dryer fire incidents, and no meaningful conclusions can be drawn from them.

The Plaintiffs have not established any objective, scientific basis for assuming that the frequency of fire investigations conducted by Travelers, other consultants or the Wright Group are representative of the total number of Electrolux or any other manufacturers' annual dryer fire incidents. Nor did they provide any basis for correlating the reported fire incidents with the causes of fires involving those appliances. Regardless, the Wright Group has circumspectly concluded that other investigators' examinations somehow corroborate the Wright Group experience and support the existence of their alleged design defects.

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[91] Document "Travelers 2009 Clothes Dryer Data.pdf" located on Wright Group hard drive at \DRYERS DEPO INFO\Electrolux\Fire Statistics & Histograms; "Travelers 2009 Clothes Dryer Data.pdf" produced on December 20, 2013.

[92] Deposition of David E. Beauregard in STANDARD FIRE INSURANCE COMPANY, a/s/o Karen Thomas v. ELECTROLUX HOME PRODUCTS, INC., February 5, 2010, pages 33-36.

5 Combustible Plastic Claims

The clothes dryers at issue in this matter that Electrolux manufactured at their Webster City, Iowa plant during the early 2000s were designed in compliance with all applicable clothes dryer standards during this period. The Electrolux clothes dryers met the voluntary product safety standards and were UL-listed and CSA-listed. The Plaintiffs have alleged that Electrolux disregarded consumer safety because the dryers were not designed to contain all fires. During this time period, there was no generally-accepted basis for designing for fire containment in clothes dryers within the laundry industry. Two manufacturers, Whirlpool and GE, have been held out as applying internal company fire containment test protocols to their dryer platforms; however, I am not aware of any other manufacturers during that time period that had similar specifications.

Internal company specifications in the industry and the later UL standard test protocol were performance-based and not material of construction-based. Based on the specifications and standards, HB-rated plastics are acceptable materials of construction for the front air duct and blower housing in these dryers. As I demonstrated earlier, Electrolux dryers with HB-rated plastic components did not pose a greater residual fire risk within the population than the background population of clothes dryers.

The Plaintiffs have alleged that Electrolux's use of HB plastic components constituted a design defect. They claim through the reports of the Wright Group and Mr. Fallows and Dr. Miller, that HB plastics caused fires to grow inside clothes dryers and to escape the cabinet. From my experience and a review of the discovery documents, their allegations are not scientifically supported and are mere speculation. Further, this combustible plastic defect hypothesis relies on Plaintiffs' specific alleged lint accumulation defect and resulting fire cause scenario, which I have demonstrated are not supported by the evidence.

The Plaintiffs' claim that changing two components, the front air duct and blower housing, from HB-rated plastic to another more fire-resistant plastic material would prevent internal fires from growing and escaping the dryer cabinet. However, they have provided no testing, fire dynamics analysis, or other reasonable basis for this conclusion. A fire inside a clothes dryer can be ignited for many reasons, but the ultimate growth of a fire is related to the internal fuels and their combustion in a confined environment. The potential for an individual clothes dryer to contain any internal fire is dependent upon many aspects of its construction, installation, cleaning, heating system type/configuration, garment load, user interaction, and the fire scenario itself. The Plaintiffs have not demonstrated that changing the composition of any plastic components will reduce or eliminate the frequency or severity of fires or fire containment involving Electrolux-manufactured dryers or any other manufacturer's dryer design.

The goal of designing a clothes dryer for containing model fires is more challenging than the Plaintiffs have implied. Until recently (March, 2009 (published), March 2013 (effective)), there was no uniform standard test protocol for a fire containment type of test. As a consequence, fire containment potential for all clothes dryers was variable and not uniformly quantifiable. Even after March 2009, the test protocol set forth in UL 2158 does not account for all potential

installation and use factors that may affect containment. Instead, the protocol provides pass/fail criteria for specific and reproducible drum fire and base fire scenarios in new clothes dryers. Such containment tests may provide a metric for improving dryer fire containment, but they cannot be used to predict how dryers with different use and installation histories will contain fires in substantially different scenarios than those tested.

In the following sections, I will address the Plaintiffs' claims regarding their seemingly simple like-for-like swap of plastics, the complexity of fire containment in a clothes dryer, and the reasonableness of Electrolux's decision to continue using HB-rated plastic in their dryer designs.

5.1 Laundry Industry Stakeholders' Approach to Fire Risk

Laundry industry stakeholders have attempted for many years to identify the predominant root causes of clothes dryer fires, but the list of potential causes has proven to be too extensive to permit design modifications in order to prevent all of the identified causes. I have enumerated many of the factors earlier in this report (i.e., Section 4), which are dominated by the uncontrollability of the installation, use, and maintenance by the appliance owner or user. The potential fire hazard involving all clothes dryers could not be eliminated through engineering design alone. Thus, in the early 2000s, industry representatives began working with representatives of State Farm Insurance, Underwriters Laboratories (UL), the Canadian Standards Association (CSA), and the U.S. Consumer Product Safety Commission (CPSC) to develop a standardized fire containment test protocol in an attempt to mitigate the consequences of clothes dryer fires. At that time, standardized and generally accepted test methods for evaluating fire containment in clothes dryers did not exist. Only a few, not all, manufacturers (e.g., GE and Whirlpool) applied forced fire tests during their clothes dryer design process. The GE SEE test was limited in its scope to non-energized, non-tumbling dryers with an alcohol-accelerated drum fire.

A joint task group was formed in 2002 under the auspices of UL to develop a standardized protocol for testing the fire containment capability of clothes dryers. I started working with the joint task group in about 2004 to assist in development of a reproducible fire test protocol and later became a member of the UL Standard Technical Panel for UL2158. The intent of the fire containment test program was to harden clothes dryer designs against internal fires in order to reduce the likelihood of an internal fire escaping. Given the nature of the appliance and the user interaction, no design changes can completely eliminate the potential for a fire to escape the cabinet. Initial test protocol variations did not prove to yield reproducible results; thus, the parties undertook considerable investigation to refine the protocol over a period of several years. A final test protocol was ultimately developed and included in the second edition of UL 2158, issued in March 2009. This change had an implementation date that was delayed four years to March 2013.

As part of the test procedure development, I personally conducted or witnessed numerous fire containment tests on multiple types of clothes dryer platforms with combustible plastic components. At the same time, UL staff conducted testing according to the draft fire containment test protocol. Tests in 2004 and 2005 showed that 72% of the dryers that they

burned failed their fire containment tests.[93] The protocol used for these tests was reported to be substantially similar to the final protocol that exists in the current edition of UL 2158. In 2011, the UL author of the white paper also concluded that most then-current clothes dryer designs were "unlikely to pass the recently added fire containment tests without some product modifications." The underlying reason for delayed adoption and enforcement dates of the test protocol is a direct result of the challenges that appliance manufacturers would need to overcome in redesigning and bringing fire containment protocol-compliant dryer platforms to the market. The state of the art for new clothes dryer designs did not encompass fire containment until 2009, at the earliest. The ball-hitch style dryers that were already UL-listed were not subject to this revised standard. It is not appropriate to make an after-the-fact engineering judgment against Electrolux's dryers that were designed and developed from the mid-1990s to the mid-2000s because those designs pre-dated the new UL fire containment test protocol.

Based on my work with this standard development process, I was able to gain additional experience and insight into the dynamics of fire growth inside clothes dryers and the factors which may lead to fire escape from the dryer cabinet. The test protocol challenged each dryer by applying two model fires in the base area and two model fires in the drum, one each with the dryer tumbling and static. I found through this work that although the UL 94-listed fire resistance of plastics may affect performance in one or more tests, other physical dryer design factors exhibited more dominant effects on the ability for a dryer to contain a fire.[94]

These tests differ significantly from the GE SEE test due to the inclusion of simulated lint in the base mechanical area under the drum, the use of a dynamic test criterion, induced ventilation during the tests, and energizing the dryer. Further, the GE SEE test does not call for a natural gas supply or burner operation in gas-heated dryers. Natural ventilation into the cabinet during the internal fire, holes or gaps in the cabinet, and door locking mechanisms were just a few examples of the design features in any individual dryer that may prevent the appliance from containing an internal fire regardless of plastic components. The fire containment test protocol and industry efforts have also focused only on electrically-heated dryers. Gas-heated dryers can present a much more aggressive fire condition due to the interaction of the burner system with an internal base fire or from a leak in the system during a fire. The gas dryer standard, ANSI/CSA Z21.5, does not apply a fire containment requirement because of the additional challenges posed by gas-fired systems, and I am not aware of any present ANSI/CSA intention of including such a provision.

A user's interaction with a clothes dryer poses the biggest challenge to fire containment. Just as occurs in many dryer fire incidents, the user can open the door and breach containment during a dryer fire. Any potential for the dryer design to contain a fire can thus be circumvented by the user.

There are additional factors that can influence containment that are primarily governed by installation and user care or maintenance. These include the quantity of lint available as fuel in

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93 Reducing injury and damage related to electric dryer fires, fire containment tests for the second edition of UL 2158. Underwriters Laboratories, Inc., 2011.

94 Morrison DR., Fire containment and clothes dryers. Appliance Magazine 2009 Nov/Dec; 66(9):16–19.

the cabinet and exhaust system, mechanical changes in the dryer over its life such as leaking seals, and the effects of natural ventilation through the appliance. Natural ventilation due to air flow into or out of the appliance based on its elevation in the residence, pressure differential between the laundry room and the exhaust termination, and other potential residence-specific and situation-specific factors can also significantly affect fire containment.

The Plaintiffs have alleged that the Electrolux-manufactured dryers were defective because they did not contain internal fires; however, they have provided no basis for opining on the potential for any dryer to contain an internal fire or a comparison to the industry state of the art for clothes dryer design during the early 2000s. Further, they have not provided any data supporting their proposition that HB-rated plastics increase the likelihood of an internal fire escaping from the dryer cabinet. Nor have they provided data showing that the use of HB plastic increases the likelihood of a fire by providing an additional fuel source.

5.2 Combustibility of Plastics

The report of Mr. Fallows and Dr. Miller claimed that a [UL 94] "5VA or 5VB rated plastic would be safer in any fire situation than an HB rated plastic."[95] Other than a recitation of the test methods used on very small plastic samples to determine these ratings, they did not provide an engineering basis for this conclusion, much less any scientific analysis of the field performance of the plastic components as they actually were used in the full appliance application. The fire-related performance of a specific part inside the clothes dryer is also a function of the construction details and the effects of other fuels inside the clothes dryer. Performance in the UL-94 laboratory tests is not directly correlated to performance in a full-scale appliance used in the field where the nature and duration of flame exposure, configuration effects, and ventilation effects all play a role.

5.2.1 Standardized Fire Testing for Polymeric Materials

The UL 94 test rating is a common metric for comparing the fire resistance of base plastic materials that are to be used in plastic components for an appliance. ANSI/UL2158 and ANSI Z21.5.1/CSA 7.1 are the governing product safety design standards for clothes dryers. ANSI Z21.5.1/CSA 7.1 does not provide any guidance or requirement for the fire resistance of plastic components. ANSI/UL2158 specifies that plastic parts, which act as electrical component enclosures, must have a fire resistance of UL 94-5VA or 94-5VB, and other functional parts such as the fan and ducting must be HB-rated or greater.[96]

In the UL 94 test method, both horizontal and vertical burning behaviors of a plastic material with respect to its ignition resistance and flame spread are examined using a small-scale apparatus. In the vertical burning test, materials passing the test criteria are classified as V-0, V-1, and V-2 when tested using a 20 mm (50 W) methane flame, whereas 5VA and 5VB classifications are given for the passing materials tested using a 125 mm (500 W) flame with a

[95] Fallows Associates report, dated December 20, 2013, page 12.

[96] UL2158 Electric Clothes Dryers, Tables 10 and 11, and Sections 32.3 and 32.4, 2003.

limited duration of application.[97,98] The horizontal burning test is performed for HB classification of materials. Bar specimens of 125 mm long by 13 mm wide by up to 13 mm thick are used for all test methods. Additional plaque specimens of 150 mm by 150 mm by up to 13 mm thick are tested for 5VA and 5VB classifications. In general, the relative resistance of tested materials for flame spread and burning according to UL 94 is HB, V-2, V-1, V-0, 5VB, and 5VA, respectively, from low to high resistance.[99]

None of these tests are conducted on a part in a confined geometry, with a continuous flame application, or with active ventilation of the fire test, all of which may be present in a clothes dryer fire outside the laboratory.

5.2.2 Plastic Performance in Laboratory Small-Scale Standardized Fire Tests vs. in a Product Application

The fire performance of plastics is a factor to be considered in the process of designing a product containing plastic components. Small-scale standard test methods (such as UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances) are often relied upon for evaluation of material flammability primarily due to their simplicity, repeatability, and relatively low cost. However, full-scale performance of plastic components in product fires can be affected by additional factors that are not represented in small-scale tests. The full-scale fire test performance of a product is not necessarily well correlated to the small-scale performance of the individual component materials.

As with many standardized test methods, UL 94 examines and classifies burning behavior of a material under the specific conditions of the test method. The scope of UL 94 states that the tests *"serve as a preliminary indication of their acceptability with respect to flammability for a particular application"* and are *"not intended to provide correlation with performance under actual service conditions."*[100] One is likely to observe actual plastic behavior in a fire by testing a product and its component plastic parts (formed as they are actually used in a product versus a flat rectangular plastic coupon) in their real world, end-use environments rather than a plastic sample in a laboratory test. The UL 94 test method may represent a realistic full-scale test when small products with intermittent potential ignition sources are of interest. However, when the fire performance of a larger product or appliance is to be evaluated, solely relying upon UL 94 test results can be inadequate.[101] A literature survey demonstrates the importance of plastic flammability evaluation based on a full-scale (product with formed plastic components) vs. plastic-coupon-only test results.

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97 Babrauskas V., Fire Test Methods for Evaluation of Fire-Retardant Efficacy in Polymeric Materials, Chapter 3 of Fire Retardancy of Polymeric Materials, Marcel Dekker, Inc., 2000, page 88.

98 UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, 2003.

99 Other UL 94 test methods including Thin Material Vertical Burning Test (VTM), Radiant Panel Flame Spread Test (RP) and Horizontal Burning Foamed Material Test (HF) are less common.

100 UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, 2003, pages 5 and 7.

101 Babrauskas V., Fire Test Methods for Evaluation of Fire-Retardant Efficacy in Polymeric Materials, Chapter 3 of Fire Retardancy of Polymeric Materials, Marcel Dekker, Inc., 2000, page 89.

An experimental study by Abbot[102] provides a comparison of small- and large-scale flammability test results on three formulations of polypropylene samples (with and without flame retardant (FR) treatment). The small-scale tests included Oxygen Index ASTM D2863 and UL 94 vertical and horizontal burn tests. Based on the UL 94 tests, two FR treated polypropylene samples had V-0 and V-2 ratings, whereas the remaining non-FR sample was HB rated. The large-scale tests were performed on a test rig consisting of a stack of horizontal polypropylene sheets with an ignition source underneath to represent a fire starting under a stack of chairs. The results from the large-scale tests indicate that the flame spread rate for all V-0, V-2, and HB samples was dependent on the initial non-plastic fuel load.[103] The study concluded that both small- and large-scale tests must be used to gain a more comprehensive understanding of flammability materials given its end-use conditions and that an assessment based on small-scale alone could be misleading and allow the use of a potentially hazardous material in the particular application involved.

A discussion on fire testing of materials by Buc addresses validity and limitations of standard fire test methods which include material composition, geometry and arrangement of test sample, ignition source and/or fire exposure, the applicability of pass/fail or performance criteria, and the applicability of individual portions of the test methods to the intended scenario given the products' end-use. The author notes that the limitations of standard test methods are that the test conditions may not capture known or potentially important fire parameters and that the standard test methods may not be sufficiently versatile for different environments and new technologies.[104]

Bundy and Ohlemiller[105,106] conducted a series of bench-scale and full-scale experiments on plastic materials to determine the accuracy of bench-scale material testing in predicting full-scale end-product fire performance. The standardized bench-scale tests included the UL 94 vertical burn, the glow wire ignitability temperature test (IEC 698-2-1/3), and the cone calorimeter test (ASTM E 1354) and were conducted on 18 plastic materials normally used in electronic equipment housings. The study found that the UL 94 test was capable of predicting the self-extinguishing behavior of the full-scale specimens exposed to small ignition source, but offered limited information on the material response to a larger ignition source. The full-scale tests also showed that all tested material (HB and V rated plastic housings) ignited and propagated fire when exposed to the larger ignition source. The authors concluded that a full-scale test remains the only certain way to obtain a definitive measure of fire hazard. This finding is consistent with my experience and also directly contrary to the Plaintiffs' claims that merely substituting components with a higher fire resistance plastic would create fire containment.

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[102] Abbot, CJ., Flame-Retarded Polypropylene: A Comparison of Large- and Small-scale Tests, Fire and Materials, Vol. 4, No. 2, 1980.

[103] The Non-FR treated sample was ignited with a smaller ignition source (8 cm crib vs. 15 cm crib).

[104] Buc, EC., Fire Testing and Fire Reality: What Do Fire Tests Really Tell Us About Materials, Conference Proceeding, Fire & Building Safety in the Single European Market, November 12, 2008.

[105] Bundy, M. and Ohlemiller ,T., Bench-Scale Flammability Measures for Electronic Equipment, National Institute of Standards and Technology, NISTIR 7031, 2003.

[106] Bundy M. and Ohlemiller, T., Full-Scale Flammability Measures for Electronic Equipment, National Institute of Standards and Technology, NIST Technical Note 1461, 2004.

Other scientific studies have attempted to quantify UL-94 plastic ratings by developing a correlation between the UL-94 rating and the heat release rate (HRR) of the plastic as measured by a cone calorimeter. Multiple studies [e.g.,107,108] have concluded that a quantitative correlation between a given plastic's UL-94 fire rating and the plastic's HRR, a measure of the power of a fire,[109] does not exist. Additionally the authors conclude that "one cannot compare the HRR results between one base polymer and another in regard to UL-94 V rating and expect to find a similar result." These results indicate that the power of a fire (HHR), and therefore the implied fire safety of a given plastic, cannot be determined solely based on the plastic's composition and UL-94 fire rating. This finding is consistent with my experience and also directly contrary to the Plaintiffs' claims that merely substituting components with a higher fire resistance plastic would create fire containment.

In an engineering handbook chapter, Tewarson et al. note the limitations and applicability of small-scale standardized tests (i.e. UL 94). They concluded that the test criteria are applicable to materials used for the construction of small parts in metallic devices and appliances exposed to small ignition sources, but that it is very difficult to assess the fire behavior of products in different shapes, sizes, and arrangements and when exposed to heat and environmental conditions other than those used in the test.[110]

These findings in the literature support the conclusion that a plastic component's performance in small-scale fire tests cannot be directly translated to a clothes dryer where lint and garments are the primary fuel loads, the plastic components are shaped differently, and where they exist in a different environment than the plastic coupons in the UL 94 test. This finding further highlights the error in Mr. Fallows' and Dr. Miller's claim that a higher fire rated plastic, based on small scale testing (e.g. UL-94), "would be safer in any fire situation than an HB rated plastic."[111] The Plaintiffs have failed to provide any testing basis for this assertion.

5.2.3 Plaintiffs' Lack of a Basis for Plastic Selection

Small-scale standardized test methods such as UL 94 are capable of capturing burning behavior of a material under the specific conditions of the test method, but they should not be relied upon unquestionably for predicting the materials' or finished products' performance to be expected in actual fires. The plastic parts used in Electrolux-manufactured clothes dryers met the corresponding safe design standards during the time period of design and manufacture. The Plaintiffs failed to demonstrate that their proposed change would have affected the outcome of any actual internal fires. They have failed to address the effects of accumulated lint, the garment load, changes over the product life, user interaction, a fuel gas heating system,

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[107] Morgan, AB., Bundy, M., Cone calorimeter analysis of UL-94 V-rated plastics, Fire and Materials. 2007; 31:257-283.

[108] Bundy, M. and Ohlemiller, T., Full-Scale Flammability Measures for Electronic Equipment, National Institute of Standards and Technology, NIST Technical Note 1461, 2004.

[109] Generally normalized by the size of the specimen, units are [power/unit area].

[110] Tewarson, A., Chin, W. and Shuford, R., Chapter 2 – Materials Specifications, Standards, and Testing, Handbook of Building Materials for Fire Protection, Edited by Harper, C.A., McGraw-Hill, 2004, pages 2.27 and 2.28.

[111] Fallows Associates report, dated December 20, 2013, page 12.

ventilation, combustion in a confined compartment, or any other factors affecting the combustibility of plastic components inside a clothes dryer.

Plaintiffs' assertion that higher UL 94-rated fire-resistant plastics would enhance fire containment lacks foundation. The literature, and the test standard itself, demonstrate that the small scale tests are not directly applicable to plastic components in the complete appliance in a real-world fire. Complex interactions of individual fire scenario factors and clothes dryer construction details determine the likelihood of fire containment.

5.3 Fire Containment

Plaintiffs offer no testing evidence that their proposed changes to the dryer plastic components would alter a fire incident in the field.

Starting in the mid-1990s, Electrolux undertook a design effort to produce dryers for GE. These dryers were required to meet GE's set of product design specifications including functional tests, appearance, construction, and compliance with the GE SEE (Severe Environmental Exposure) test. The GE SEE test is a fire containment test that only tests the ability of the dryer to contain a drum fire during a static, de-energized state.[112] This test does not replicate the current (2013) state-of-the-art UL fire containment test protocol or a real fire incident involving an operating clothes dryer. This test best approximates the spontaneous combustion of a drum load in an idle dryer. A drum fire containment test performed with the dryer running may accelerate fire growth in relation to a static, non-operating test because of the airflow caused by the blower. Furthermore, if the dryer is energized during a fire test (whether the blower is running or not), electrical shorting and arcing can lead to a failure of fire containment and can also energize the blower causing the dryer to temporarily run.[113] An in-the-field real-world dryer may experience all of these conditions, but they are not simulated by the GE SEE test. The GE SEE test will not represent the effects of a base fire in a dryer; thus, there is no basis to conclude that a design that passes the GE SEE test will also contain all real clothes dryer fire scenarios.

Mr. Fallows and Dr. Miller referred to fire tests conducted by Electrolux in 1995 on early prototypes in the Alliance dryer platform and the predecessor Mansfield design in accordance with the GE SEE test protocol. The discovery documents and testimony are insufficient to understand the full scope of the design process that Electrolux undertook during the GE dryer design program; thus, these consultants made inferences about the undocumented parts of the design process. The GE dryer design contained different construction features that affect the potential for fire containment including a different console and top panel from the dryers that Electrolux manufactured for sale under their own brands.[114] Although the Plaintiffs have inferred that the only difference was HB versus 5V plastic in the air duct, it is clear that the GE dryer design was not the same.

[112] EHP LARSON 277046-277047.

[113] This phenomenon was demonstrated in the WGI and Traveler's full burn tests located on the Wright Group hard drive at \DRYERS DEPO INFO\Electrolux\Electrolux Testing\WGI & Traveler's_Electrolux_Dryer Testing Nov_Dec 2008.

[114] Deposition of Brian Ripley, July 24, 2013, pages 223-224.

Two FMECA worksheets from the GE design program dated in October, 1998, were referenced by Mr. Fallows' and Dr. Miller's report.[115] GE did not produce other documents that gave context to these worksheets, nor did GE produce any FMECA narrative reports; thus, these worksheets' relationship to the overall design program should be cautiously interpreted. These two worksheets address the Pipeline Dryer, Console Bottom and Top Panel, which are different components from those used in Electrolux branded designs, as mentioned earlier. No basis was provided for the listed Severity Ratings, Occurrence Ratings, or Detection Ratings; thus, any attempt to recreate the thought process of the FMECA team is mere speculation. The apparent objectives of the FMECAs were to pass the GE SEE test, which Electrolux was able to do by altering the internal barriers around the openings in these components. No similar FMECA worksheets were provided on the front air duct or blower housing. The discovery documents only indicate that the GE designs passed the SEE test; no documentation was provided that indicated that Electrolux tested the GE design or production Alliance design against the SEE protocol with an HB-rated front air duct.

Mr. Fallows and Dr. Miller incorrectly assumed that passing the SEE test by making a plastic component material change will mitigate internal spread and lead to containment of fires in clothes dryers. My experience with the UL fire containment test protocol, of which, only one test is similar to the SEE test, does not support a conclusion that a single plastic component change will affect the spread and containment of internal dryer fires. As an example, Mr. Ripley testified that the use of 5VA air ducts in the prototype Portland bulkhead designs did not perform significantly differently from HB plastic tests during fire containment tests.[116] From the Wright Group hard drive, there are also several examples of non-Electrolux-manufactured GE brand clothes dryers that were significantly fire damaged.

These dryer designs had presumably passed the GE SEE test; however, they were still involved in fires that escaped the cabinet. There was insufficient documentation to determine the cause or other factors for these dryers, but the photographs indicate that these dryers had internal fires that escaped from the dryer cabinet. Examples of three dryers demonstrating increasing level of damage to the dryer cabinets are provided in Figure 36 to Figure 38. In 2009, the Wright Group conducted a fire containment test on a non-Electrolux-manufactured GE dryer. In that drum fire test, the dryer did not contain the fire as depicted in Figure 39. I also recently participated in the examination of a burned Electrolux-manufactured GE-branded clothes dryer with Mr. Parsons at the Wright Group that showed identical damages to other dryers (see Figure 40).[117] This dryer had date code LME, corresponding to manufacture in December, 2005. According to Mr. King, this unit would have had a 5V-rated front air duct.[118]

[115] EHP LARSON 333355-333356.

[116] Deposition of Brian Ripley, July 24, 2013, pages 160-169.

[117] I have not concluded my investigation or analysis in this matter. The photograph is only for comparison purposes. The matter is Nitti, Wright Group Case #59700.

[118] Deposition of Carl King, September 6, 2013, King Exhibit 167.

Image from Wright Group Hard Drive: \DRYERS DEPO INFO\GE\Dryers\GE Dryers_Electric\WGI#56072_GE_DVLR223EE1WW_ZH755652A\56072_11-13-2007_TR. IMG_0010.JPG

Figure 36. Fire-damaged GE brand clothes dryer - “WGI#56072_GE_DVLR223EE1WW_ZH755652A.”

Image from Wright Group Hard Drive: \DRYERS DEPO INFO\GE\Dryers\GE Dryers_Electric\WGI#58642_GE_DBLR333EG0WW_AM747632A_Jan 2007, 58642_12-02-2011_MS.pdf, IMG_0009.JPG

Figure 37. Fire-damaged GE brand clothes dryer - “WGI#58642_ GE_DBLR333EG0WW_AM747632A_Jan 2007.”

Image from Wright Group Hard Drive: \DRYERS DEPO INFO\GE\Dryers\GE Dryers_Electric\EXEMPLAR_GE-ELEC-E, IMG_0679.JPG

Figure 38. Fire-damaged GE brand clothes dryer - “EXEMPLAR_GE-ELEC-E.”

From image “Door trap duct_0084.jpg” in photos.pdf, Wright Group hard drive \DRYERS DEPO INFO\GE\GE Testing\Dryer door trap duct burn nov 2009\photos

Figure 39. Wright Group drum fire containment test in 2009. The internal fire caused the door to open during the test.

Figure 40. Photograph of 2005 Electrolux-manufactured and GE-branded clothes dryer that was involved in a fire.

These GE branded dryer fires demonstrate that even products that presumably had to pass GE's SEE test do not contain fires in the field. These examples show that designing a dryer for fire containment of uncontrolled, real-world fires involving accumulated lint or the garment load is difficult. A new, unused dryer that passes the GE SEE test does not represent the performance of a clothes dryer in all real fire scenarios. Use of 5V plastics does not affect the likelihood of a fire igniting inside a dryer nor whether the dryer will contain the subsequent fire. Since I do not know the incident facts surrounding these dryers, other than the 2009 test, I also cannot rule out user interaction with the dryer during the fire. If the dryer door opens during a fire incident, the likelihood of fire containment is further reduced.

5.4 Evaluation of Combustible Plastic Claims

Mr. Fallows and Dr. Miller alleged that Electrolux's use of HB plastic components was "illogical and reckless;"[119] however, they failed to analyze the functional use of the plastic components or the effects of a confined fire inside the clothes dryer. Compliance with limited fire containment tests, such as the GE SEE test, may mitigate a specific fire scenario. Yet, my experience, the fire test literature, industry fire statistics, Electrolux's experience, and examples from the Wright Group hard drive demonstrate that there are many potential fire scenarios that may lead to a breach of fire containment regardless of the fire resistance rating of plastic components. The Plaintiffs have failed to demonstrate that the use of a 5V-rated plastic air duct

[119] Fallows Associates report, dated December 20, 2013, page 15.

would materially alter fire ignition and growth in any of the named Plaintiffs' dryers or any other Electrolux-manufactured dryer.

Electrolux dryers complied with all applicable clothes dryer standards evidenced by their UL and CSA certifications. Until 2009, there was no generally-accepted specification or test for fire containment in the laundry industry. HB plastics were acceptable materials of construction for the front air duct and blower housing. The Plaintiffs have not demonstrated that Electrolux dryers with HB plastic components posed a greater fire risk within the population than other clothes dryers manufactured during the early 2000s.

6 Closing

At the request of Brouse McDowell on behalf of Electrolux Home Products, Inc., Exponent conducted an investigation into and assessment of the design defect allegations made by the Plaintiffs in regard to fire safety of Electrolux-manufactured ball-hitch clothes dryers. This report was authored in regard to United States District Court for the Western District of Wisconsin, Case No.: 3:11-cv-00678 (SLC), captioned as American Family Mutual Insurance Company, General Casualty Company of Wisconsin, Country Mutual Insurance Company, and Wisconsin Mutual, Plaintiffs v. Electrolux Home Products, Defendant.

This report addressed the design defect allegations proposed by Mr. Ronald Parsons and Mr. Michael Stoddard of the Wright Group, Inc. (Wright Group) and Mr. Joe Fallows and Dr. Sam Miller of Fallows Associates (Fallows) in regard to Electrolux ball-hitch style dryers manufactured in Webster City, Iowa. Specific facts of each investigation are unique to that incident and must be considered during evaluation of the cause of a specific fire incident involving an individual clothes dryer. This report provided the background necessary to understand clothes dryers and the residual fire risk, and it evaluated the Wright Group's and Fallow's alleged design defects.

Regardless of the logical errors and inconsistencies in the Plaintiffs' consultants' uniform design defect allegations, they have routinely failed to demonstrate that the most likely cause of an individual fire involving a clothes dryer was uniquely consistent with their alleged defects. Furthermore, the factual differences between each specific dryer model and incident are significant, and the installation, operating environment, and individual use and maintenance history of each dryer will vary widely. The Plaintiffs have neglected to address the dominant role that these factors (e.g., venting) play in the likelihood of whether any dryer, Electrolux-manufactured or not, will be involved in a fire.

In many individual incidents, there is no supportive evidence of the Plaintiffs' allegation of lint accumulation behind the dryer drum prior to the fire. Instead, physical evidence is commonly either contradictory or supports a hypothesis of fire progression from the base into the air duct, which is contrary to the Plaintiffs' allegations, and is instead consistent with a failure to clean accumulated lint out of the cabinet coupled with inadequate exhaust venting over the life of the dryers.

The Plaintiffs' consultants have consistently ignored physical evidence and witness observations that contradict the Plaintiffs' uniform lint design defect hypothesis. More likely credible causes have been frequently dismissed in a clear application of expectation bias. Contributions of the installation, use and maintenance history, and the environment to which the dryers were exposed are also frequently ignored by the Plaintiffs' consultants. Although credible competing hypotheses can be developed to explain most fire incidents, there is commonly insufficient evidence to rule out multiple fire causes. Thus, the causes of individual fires should often be listed as undetermined, a conclusion which is consistent with good scientific fire investigation practice; however, the Plaintiffs' consultants opine that the fires were caused by design defects.

The Plaintiffs alleged that two design defects exist in Electrolux-manufactured ball-hitch clothes dryers: a uniform lint accumulation and ignition design defect and a plastic and fire containment design defect. Upon scientific examination, the bases, assumptions, and Plaintiffs' consultants' conclusions were readily shown to be based on the use of biased data sets, unfounded assumptions, and non-scientific conclusions. The Electrolux ball-hitch style clothes dryer is not a defective design and was designed in compliance with all applicable standards.